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401 M STREET, SW
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This background document provides the Agency's rationale and technical support for selecting the constituents to be regulated in K062 waste and for developing treatment standards for those regulated constituents. The document also provides waste characterization and treatment information that serves as a basis for determining whether variances may be warranted. EPA may grant a treatment variance in cases where the Agency determines that the waste in question is more difficult to treat than the wastes upon which the BDAT treatment standards are based.

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FINAL

BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)
BACKGROUND DOCUMENT FOR
K062

James R. Berlow, Chief
Treatment Technology Section

Monica Chatmon
Project Manager

U.S. Environmental Protection Agency
Office of Solid Waste
401 M Street, S.W.
Washington, D.C. 20460

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EXECUTIVE SUMMARY

BDAT Treatment Standards for K062

Pursuant to the Hazardous and Solid Waste Amendments (HSWA) enacted on November 8, 1984, the Environmental Protection Agency (EPA) is establishing best demonstrated available technology (BDAT) treatment standards for the listed waste identified in 40 CFR 261.32 as K062. Compliance with these BDAT treatment standards is a prerequisite for placement of the waste in units designated as land disposal units according to 40 CFR Part 268. The effective date of these treatment standards is August 8, 1988.

This background document provides the Agency's rationale and technical support for selecting the constituents to be regulated in K062 waste and for developing treatment standards for those regulated constituents. The document also provides waste characterization and treatment information that serves as a basis for determining whether variances may be warranted. EPA may grant a treatment variance in cases where the Agency determines that the waste in question is more difficult to treat than the wastes upon which the BDAT treatment standards are based.

The introductory section, which appears verbatim in all the First Third background documents, summarizes the Agency's legal authority and promulgated methodology for establishing treatment standards and discusses the petition process necessary for requesting a variance from the treatment standards. The remainder of the document presents waste-specific information: the number and locations of facilities affected by the land disposal restrictions for K062 waste, the waste-generating process, characterization data, the technologies used to treat the waste (or similar wastes), and available performance data, including data on which the treatment standards are based. The document also explains EPA's determination of BDAT, selection of constituents to be regulated, and calculation of treatment standards.

K062 waste is listed as spent pickle liquor generated by steel finishing operations. The Agency estimates that approximately 978 facilities in the iron and steel industry potentially generate K062 waste. These facilities fall under the Standard Industrial Classification (SIC) Codes 331 and 332.

The Agency is regulating three metal constituents in the wastewater forms of K062 waste and two metal constituents in nonwastewater forms. (For the purpose of determining the applicability of the BDAT treatment standards, wastewaters are defined as wastes containing less than 1 percent (weight basis) total suspended solids* and less than 1 percent (weight basis) total organic carbon (TOC). Waste not meeting this definition must comply with the treatment standards for nonwastewaters.)

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*The term "total suspended solids" (TSS) clarifies EPA's previously used terminology of "total solids" and "filterable solids." Specifically, total suspended solids is measured by method 209C (Total Suspended Solids Dried at 103-105°C) in Standard Methods for the Examination of Water and Wastewater, Sixteenth Edition.

The treatment standards for the metal constituents in both nonwastewater and wastewater are based on performance data from chromium reduction, followed by chemical precipitation, and settling, filtering, and dewatering of solids.

The following table presents the specific BDAT treatment standards for K062 nonwastewater and wastewater. For the BDAT list metal constituents, treatment standards in the nonwastewater reflect the concentration of constituents in the leachate from the Toxicity Characteristic Leaching Procedure (TCLP) and treatment standards in the wastewater reflect the total constituent concentration. The units for the total constituent concentration are mg/kg (parts per million on a weight-by-weight basis) for the nonwastewater and mg/l (parts per million on a weight-by-volume basis) for the wastewater. The units for the leachate concentration are mg/l (parts per million on a weight-by-volume basis). If the concentrations of the regulated constituents in the K062, as generated, are lower than or equal to the BDAT treatment standards, then treatment is not necessary as a prerequisite to land disposal.

Testing procedures for all sample analyses performed for the regulated constituents are specifically identified in Appendix B of this background document.

BDAT Treatment Standards for K062

Constituent	Maximum for any single grab sample		
	Nonwastewater		Wastewater
	Total concentration (mg/kg)	TCLP leachate concentration (mg/l)	Total concentration (mg/l)
Chromium	NA	0.094	0.32
Lead	NA	0.37	0.04
Nickel	NA	NA	0.44

NA = Not applicable.

1. INTRODUCTION

This section of the background document presents a summary of the legal authority pursuant to which the best demonstrated available technology (BDAT) treatment standards were developed, a summary of EPA's promulgated methodology for developing the BDAT treatment standards, and, finally, a discussion of the petition process that should be followed to request a variance from the BDAT treatment standards.

1.1 Legal Background

1.1.1 Requirements Under HSWA

The Hazardous and Solid Waste Amendments of 1984 (HSWA), which were enacted on November 8, 1984, and which amended the Resource Conservation and Recovery Act of 1976 (RCRA), impose substantial new responsibilities on those who handle hazardous waste. In particular, the amendments require the Agency to promulgate regulations that restrict the land disposal of untreated hazardous wastes. In its enactment of HSWA, Congress stated explicitly that "reliance on land disposal should be minimized or eliminated, and land disposal, particularly landfill and surface impoundment, should be the least favored method for managing hazardous wastes" (RCRA section 1002(b)(7), 42 U.S.C. 6901(b)(7)).

One part of the amendments specifies dates on which particular groups of untreated hazardous wastes will be prohibited from land disposal unless "it has been demonstrated to the Administrator, to a reasonable degree of certainty, that there will be no migration of hazardous constituents from the disposal unit or injection zone for as long as the wastes remain hazardous" (RCRA section 3004(d)(1), (e)(1), (g)(5), 42 U.S.C. 6924 (d)(1), (e)(1), (g)(5)).

For the purpose of the restrictions, HSWA defines land disposal "to include, but not be limited to, any placement of . . . hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation, or underground mine or cave" (RCRA section 3004(k), 42 U.S.C. 6924(k)). Although HSWA defines land disposal to include injection wells, such disposal of solvents, dioxins, and certain other wastes, known as the California List wastes, is covered on a separate schedule (RCRA section 3004(f)(2), 42 U.S.C. 6924 (f)(2)). This schedule requires that EPA develop land disposal restrictions for deep well injection by August 8, 1988.

The amendments also require the Agency to set "levels or methods of treatment, if any, which substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized" (RCRA section 3004(m)(1), 42 U.S.C. 6924 (m)(1)). Wastes that satisfy such levels or methods of treatment established by EPA, i.e., treatment standards, are not prohibited from being land disposed.

In setting treatment standards for listed or characteristic wastes, EPA may establish different standards for particular wastes within a single waste code with differing treatability characteristics. One such characteristic is the physical form of the waste. This frequently leads to different standards for wastewaters and nonwastewaters. Alternatively, EPA can establish a treatment standard that is applicable to more than one waste code when, in EPA's judgment, a particular constituent present in the wastes can be treated to the same concentration in all the wastes.

In those instances where a generator can demonstrate that the standard promulgated for the generator's waste cannot be achieved, the amendments allow the Agency to grant a variance from a treatment standard by revising the treatment standard for that particular waste through rulemaking procedures. (A further discussion of treatment variances is provided in Section 1.3.)

The land disposal restrictions are effective when promulgated unless the Administrator grants a national variance and establishes a different date (not to exceed 2 years beyond the statutory deadline) based on "the earliest date on which adequate alternative treatment, recovery, or disposal capacity which protects human health and the environment will be available" (RCRA section 3004(h)(2), 42 U.S.C. 6924 (h)(2)).

If EPA fails to set treatment standards by the statutory deadline for any hazardous waste in the First Third or Second Third waste groups (see Section 1.1.2), the waste may not be disposed in a landfill or surface impoundment unless the facility is in compliance with the minimum technological requirements specified in section 3004(o) of RCRA. In addition, prior to disposal, the generator must certify to the Administrator that the availability of treatment capacity has been investigated, and it has been determined that disposal in a landfill or surface impoundment is the only practical alternative to treatment currently available to the generator. This restriction on the use of landfills and surface impoundments applies until EPA sets treatment standards for the waste or until May 8, 1990, whichever is sooner. If the Agency fails to set treatment standards for any ranked hazardous waste by May 8, 1990, the waste is automatically prohibited from land disposal unless the waste is placed in a land disposal unit that is the subject of a successful "no migration" demonstration (RCRA section 3004(g), 42 U.S.C. 6924(g)). "No migration" demonstrations are based on case-specific petitions that show there will be no migration of hazardous constituents from the unit for as long as the waste remains hazardous.

1.1.2 Schedule for Developing Restrictions

Under section 3004(g) of RCRA, EPA was required to establish a schedule for developing treatment standards for all wastes that the Agency had listed as hazardous by November 8, 1984. Section 3004(g) required that this schedule consider the intrinsic hazards and volumes associated with each of these wastes. The statute required EPA to set treatment standards according to the following schedule:

1. Solvent and dioxin wastes by November 8, 1986;
2. The "California List" wastes by July 8, 1987;
3. At least one-third of all listed hazardous wastes by August 8, 1988 (First Third);

4. At least two-thirds of all listed hazardous wastes by June 8, 1989 (Second Third); and

5. All remaining listed hazardous wastes and all hazardous wastes identified as of November 8, 1984, by one or more of the characteristics defined in 40 CFR Part 261 by May 8, 1990 (Third Third).

The statute specifically identified the solvent wastes as those covered under waste codes F001, F002, F003, F004, and F005; it identified the dioxin-containing hazardous wastes as those covered under waste codes F020, F021, F022, and F023.

Wastes collectively known as the California List wastes, defined under section 3004(d) of HSWA, are liquid hazardous wastes containing metals, free cyanides, PCBs, corrosives (i.e., a pH less than or equal to 2.0), and any liquid or nonliquid hazardous waste containing halogenated organic compounds (HOCs) above 0.1 percent by weight. Rules for the California List were proposed on December 11, 1986, and final rules for PCBs, corrosives, and HOC-containing wastes were established August 12, 1987. In that rule, EPA elected not to establish treatment standards for metals. Therefore, the statutory limits became effective.

On May 28, 1986, EPA published a final rule (51 FR 19300) that delineated the specific waste codes that would be addressed by the First Third, Second Third, and Third Third land disposal restriction rules. This schedule is incorporated into 40 CFR 268.10, 268.11, and 268.12.

1.2 Summary of Promulgated BDAT Methodology

In a November 7, 1986, rulemaking, EPA promulgated a technology-based approach to establishing treatment standards under section 3004(m).

Congress indicated in the legislative history accompanying the HSWA that "[t]he requisite levels of [sic] methods of treatment established by the Agency should be the best that has been demonstrated to be achievable," noting that the intent is "to require utilization of available technology" and not a "process which contemplates technology-forcing standards" (Vol. 130 Cong. Rec. S9178 (daily ed., July 25, 1984)). EPA has interpreted this legislative history as suggesting that Congress considered the requirement under section 3004(m) to be met by application of the best demonstrated and achievable (i.e., available) technology prior to land disposal of wastes or treatment residuals. Accordingly, EPA's treatment standards are generally based on the performance of the best demonstrated available technology (BDAT) identified for treatment of the hazardous constituents. This approach involves the identification of potential treatment systems, the determination of whether they are demonstrated and available, and the collection of treatment data from well-designed and well-operated systems.

The treatment standards, according to the statute, can represent levels or methods of treatment, if any, that substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents. Wherever possible, the Agency prefers to establish BDAT treatment standards as "levels" of treatment (i.e., performance standards), rather than to require the use of specific treatment "methods." EPA believes that concentration-based treatment levels offer the regulated community greater flexibility to develop and implement compliance strategies, as well as an incentive to develop innovative technologies.

1.2.1 Waste Treatability Group

In developing the treatment standards, EPA first characterizes the waste(s). As necessary, EPA may establish treatability groups for wastes having similar physical and chemical properties. That is, if EPA believes that hazardous constituents in wastes represented by different waste codes could be treated to similar concentrations using identical technologies, the Agency combines the wastes into one treatability group. EPA generally considers wastes to be similar when they are both generated from the same industry and from similar processing stages. In addition, EPA may combine two or more separate wastes into the same treatability group when data are available showing that the waste characteristics affecting performance are similar or that one of the wastes in the group, the waste from which treatment standards are to be developed, is expected to be most difficult to treat.

Once the treatability groups have been established, EPA collects and analyzes data on identified technologies used to treat the wastes in each treatability group. The technologies evaluated must be demonstrated on the waste or a similar waste and must be available for use.

1.2.2 Demonstrated and Available Treatment Technologies

Consistent with legislative history, EPA considers demonstrated technologies to be those that are currently used on a full-scale basis to treat the waste of interest or a waste judged to be similar (see 51 FR 40588, November 7, 1986). EPA also will consider as demonstrated treatment those technologies used to separate or otherwise process chemicals and other materials on a full-scale basis. Some of these technologies clearly are applicable to waste treatment, since the wastes are similar to raw materials processed in industrial applications.

For most of the waste treatability groups for which EPA will promulgate treatment standards, EPA will identify demonstrated technologies either through review of literature related to current waste treatment practices or on the basis of information provided by specific facilities currently treating the waste or similar wastes.

In cases where the Agency does not identify any facilities treating wastes represented by a particular waste treatability group, EPA may transfer a finding of demonstrated treatment. To do this, EPA will compare the parameters affecting treatment selection for the waste treatability group of interest to other wastes for which demonstrated technologies already have been determined. (The parameters affecting treatment selection and their use for this waste are described in Section 3.2 of this document.) If the parameters affecting treatment selection are similar, then the Agency will consider the treatment technology also to be demonstrated for the waste of interest. For example, EPA considers rotary kiln incineration to be a demonstrated technology for many waste codes containing hazardous organic constituents, high total organic content, and high filterable solids content, regardless of whether any facility is currently treating these wastes. The basis for this determination is data found in literature and data generated by EPA confirming the use of rotary kiln incineration on wastes having the above characteristics.

If no full-scale treatment or recovery operations are identified for a waste or wastes with similar physical or chemical characteristics that affect treatment selection, the Agency will be unable to identify any demonstrated treatment technologies for the waste, and, accordingly, the waste will be prohibited from land disposal (unless handled in accordance with the exemption and variance provisions of the rule). The Agency is, however, committed to establishing treatment standards as soon as new or improved treatment processes are demonstrated (and available).

Operations only available at research facilities, pilot- and bench-scale operations, will not be considered in identifying demonstrated treatment technologies for a waste. Nevertheless, EPA may use data generated at research facilities in assessing the performance of demonstrated technologies.

As discussed earlier, Congress intended that technologies used to establish treatment standards under section 3004(m) be not only "demonstrated," but also "available." To decide whether demonstrated technologies may be considered "available," the Agency determines whether they (1) are commercially available and (2) substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste. These criteria are discussed below.

1. Commercially available treatment. If the demonstrated treatment technology is a proprietary or patented process that is not generally available, EPA will not consider the technology in its determination of the treatment standards. EPA will consider proprietary or patented processes available if it determines that the treatment method can be purchased or licensed from the proprietor or is a commercially available treatment. The services of the commercial facility offering this technology often can be purchased even if the technology itself cannot be purchased.

2. Substantial treatment. To be considered "available," a demonstrated treatment technology must "substantially diminish the toxicity" of the waste or "substantially reduce the likelihood of migration of hazardous constituents" from the waste in accordance with section 3004(m). By requiring that substantial treatment be achieved in order to set a treatment standard, the statute ensures that all wastes are adequately treated before being placed in or on the land and ensures that the Agency does not require a treatment method that provides little or no environmental benefit. Treatment will always be deemed substantial if it results in nondetectable levels of the hazardous constituents of concern (provided the nondetectable levels are low relative to the concentrations in the untreated waste). If nondetectable levels are not achieved, then a determination of substantial treatment will be made on a case-by-case basis. This approach is necessary because of the difficulty of establishing a meaningful guideline that can be applied broadly to the many wastes and technologies to be considered. EPA will consider the following factors in an effort to evaluate whether a technology provides substantial treatment on a case-by-case basis:

   - Number and types of constituents treated;

   - Performance (concentration of the constituents in the treatment residuals); and

   - Percent of constituents removed.

EPA will only set treatment standards based on a technology that meets both availability criteria. Thus, the decision to classify a technology as "unavailable" will have a direct impact on the treatment standard. If the best demonstrated technology is unavailable, the treatment standards will be based on the next best demonstrated treatment technology determined to be available. To the extent that the resulting treatment standards are less stringent, greater concentrations of hazardous constituents in the treatment residuals could be placed in land disposal units.

There also may be circumstances in which EPA concludes that for a given waste none of the demonstrated treatment technologies are "available" for purposes of establishing the 3004(m) treatment performance standards. Subsequently, these wastes will be prohibited from continued placement in or on the land unless managed in accordance with applicable exemptions and variance provisions. The Agency is, however, committed to establishing new treatment standards as soon as new or improved treatment processes become available.

1.2.3 Collection of Performance Data

Performance data on the demonstrated available technologies are evaluated by the Agency to determine whether the data are representative of well-designed and well-operated treatment systems. Only data from well-designed and well-operated systems are considered in determining BDAT. The data evaluation includes data already collected directly by

EPA and/or data provided by industry. In those instances where additional data are needed to supplement existing information, EPA collects additional data through a sampling and analysis program. The principal elements of this data collection program are: (1) the identification of facilities for site visits, (2) the engineering site visit, (3) the sampling and analysis plan, (4) the sampling visit, and (5) the onsite engineering report.

(1) Identification of facilities for site visits. To identify facilities that generate and/or treat the waste of concern, EPA uses a number of information sources. These include Stanford Research Institute's Directory of Chemical Producers; EPA's Hazardous Waste Data Management System (HWDMS); the 1986 Treatment, Storage, Disposal Facility (TSDF) National Screening Survey; and EPA's Industry Studies Data Base. In addition, EPA contacts trade associations to inform them that the Agency is considering visits to facilities in their industry and to solicit their assistance in identifying facilities for EPA to consider in its treatment sampling program.

After identifying facilities that treat the waste, EPA uses this hierarchy to select sites for engineering visits: (1) generators treating single wastes on site; (2) generators treating multiple wastes together on site; (3) commercial treatment, storage, and disposal facilities (TSDFs); and (4) EPA in-house treatment. This hierarchy is based on two concepts: (1) to the extent possible, EPA should develop treatment standards from data produced by treatment facilities handling only a single waste, and (2) facilities that routinely treat a specific waste have had the best opportunity to optimize design parameters. Although excellent treatment can occur at many facilities that are not high in this hierarchy, EPA has adopted this approach to avoid, when possible, ambiguities related to the mixing of wastes before and during treatment.

When possible, the Agency will evaluate treatment technologies using full-scale treatment systems. If performance data from properly designed and operated full-scale systems treating a particular waste or a waste judged to be similar are not available, EPA may use data from research facility operations. Whenever research facility data are used, EPA will explain in the preamble and background document why such data were used and will request comments on the use of such data.

Although EPA's data bases provide information on treatment for individual wastes, the data bases rarely provide data that support the selection of one facility for sampling over another. In cases where several treatment sites appear to fall into the same level of the hierarchy, EPA selects sites for visits strictly on the basis of which facility could most expeditiously be visited and later sampled if justified by the engineering visit.

(2) Engineering site visit. Once a treatment facility has been selected, an engineering site visit is made to confirm that a candidate for sampling meets EPA's criteria for a well-designed facility and to

ensure that the necessary sampling points can be accessed to determine operating parameters and treatment effectiveness. During the visit, EPA also confirms that the facility appears to be well operated, although the actual operation of the treatment system during sampling is the basis for EPA's decisions regarding proper operation of the treatment unit. In general, the Agency considers a well-designed facility to be one that contains the unit operations necessary to treat the various hazardous constituents of the waste, as well as to control other nonhazardous materials in the waste that may affect treatment performance.

In addition to ensuring that a system is reasonably well designed, the engineering visit examines whether the facility has a way to measure the operating parameters that affect performance of the treatment system during the waste treatment period. For example, EPA may choose not to sample a treatment system that operates in a continuous mode, for which an important operating parameter cannot be continuously recorded. In such systems, instrumentation is important in determining whether the treatment system is operating at design values during the waste treatment period.

(3) Sampling and analysis plan. If after the engineering site visit the Agency decides to sample a particular plant, the Agency will then develop a site-specific sampling and analysis plan (SAP) according to the Generic Quality Assurance Project Plan for the Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-87-011. In brief, the SAP discusses where the Agency plans to sample, how the samples will be taken, the frequency

of sampling, the constituents to be analyzed and the method of analysis, operational parameters to be obtained, and specific laboratory quality control checks on the analytical results.

The Agency will generally produce a draft of the site-specific SAP within 2 to 3 weeks of the engineering visit. The draft of the SAP is then sent to the plant for review and comment. With few exceptions, the draft SAP should be a confirmation of data collection activities discussed with the plant personnel during the engineering site visit. EPA encourages plant personnel to recommend any modifications to the SAP that they believe will improve the quality of the data.

It is important to note that sampling of a plant by EPA does not mean that the data will be used in the development of BDAT treatment standards. EPA's final decision on whether to use data from a sampled plant depends on the actual analysis of the waste being treated and on the operating conditions at the time of sampling. Although EPA would not plan to sample a facility that was not ostensibly well designed and well operated, there is no way to ensure that at the time of the sampling the facility will not experience operating problems. Additionally, EPA statistically compares its test data to suitable industry-provided data, where available, in its determination of what data to use in developing treatment standards. The methodology for comparing data is presented later in this section.

(Note: Facilities wishing to submit data for consideration in the development of BDAT standards should, to the extent possible, provide sampling information similar to that acquired by EPA. Such facilities should review the Generic Quality Assurance Project Plan for the Land Disposal Restrictions Program ("BDAT"), which delineates all of the quality control and quality assurance measures associated with sampling and analysis. Quality assurance and quality control procedures are summarized in Section 1.2.6 of this document.)

(4) Sampling visit. The purpose of the sampling visit is to collect samples that characterize the performance of the treatment system and to document the operating conditions that existed during the waste treatment period. At a minimum, the Agency attempts to collect sufficient samples of the untreated waste and solid and liquid treatment residuals so that variability in the treatment process can be accounted for in the development of the treatment standards. To the extent practicable, and within safety constraints, EPA or its contractors collect all samples and ensure that chain-of-custody procedures are conducted so that the integrity of the data is maintained.

In general, the samples collected during the sampling visit will have already been specified in the SAP. In some instances, however, EPA will not be able to collect all planned samples because of changes in the facility operation or plant upsets; EPA will explain any such deviations from the SAP in its follow-up onsite engineering report.

(5) Onsite engineering report. EPA summarizes all its data collection activities and associated analytical results for testing at a facility in a report referred to as the onsite engineering report (OER). This report characterizes the waste(s) treated, the treated residual concentrations, the design and operating data, and all analytical results including methods used and accuracy results. This report also describes any deviations from EPA's suggested analytical methods for hazardous wastes that appear in Test Methods for Evaluating Solid Waste, SW-846, Third Edition, November 1986.

After the OER is completed, the report is submitted to the waste generator and/or treater for review. This review provides a final opportunity for claiming any information contained in the report as confidential. Following the review and incorporation of comments, as appropriate, the report is made available to the public with the exception of any material claimed as confidential.

1.2.4 Hazardous Constituents Considered and Selected for Regulation

(1) Development of BDAT list. The list of hazardous constituents within the waste codes that are targeted for treatment is referred to by the Agency as the BDAT constituent list. This list, provided as Table 1-1, is derived from the constituents presented in 40 CFR Part 261, Appendices VII and VIII, as well as several ignitable constituents used as the basis of listing wastes as F003 and F005. These sources provide a

Table 1-1 BDAT Constituent List

BDAT reference no.	Constituent	CAS no.
	Volatile organics	
222.	Acetone	67-64-1
1.	Acetonitrile	75-05-8
2.	Acrolein	107-02-8
3.	Acrylonitrile	107-13-1
4.	Benzene	71-43-2
5.	Bromodichloromethane	75-27-4
6.	Bromomethane	74-83-9
223.	n-Butyl alcohol	71-36-3
7.	Carbon tetrachloride	56-23-5
8.	Carbon disulfide	75-15-0
9.	Chlorobenzene	108-90-7
10.	2-Chloro-1,3-butadiene	126-99-8
11.	Chlorodibromomethane	124-48-1
12.	Chloroethane	75-00-3
13.	2-Chloroethyl vinyl ether	110-75-8
14.	Chloroform	67-66-3
15.	Chloromethane	74-87-3
16.	3-Chloropropene	107-05-1
17.	1,2-Dibromo-3-chloropropane	96-12-8
18.	1,2-Dibromoethane	106-93-4
19.	Dibromomethane	74-95-3
20.	trans-1,4-Dichloro-2-butene	110-57-6
21.	Dichlorodifluoromethane	75-71-8
22.	1,1-Dichloroethane	75-34-3
23.	1,2-Dichloroethane	107-06-2
24.	1,1-Dichloroethylene	75-35-4
25.	trans-1,2-Dichloroethene	156-60-5
26.	1,2-Dichloropropane	78-87-5
27.	trans-1,3-Dichloropropene	10061-02-6
28.	cis-1,3-Dichloropropene	10061-01-5
29.	1,4-Dioxane	123-91-1
224.	2-Ethoxyethanol	110-80-5
225.	Ethyl acetate	141-78-6
226.	Ethyl benzene	100-41-4
30.	Ethyl cyanide	107-12-0
227.	Ethyl ether	60-29-7
31.	Ethyl methacrylate	97-63-2
214.	Ethylene oxide	75-21-8
32.	Iodomethane	74-88-4
33.	Isobutyl alcohol	78-83-1
228.	Methanol	67-56-1
34.	Methyl ethyl ketone	78-93-3

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Volatile organics (continued)	
229.	Methyl isobutyl ketone	108-10-1
35.	Methyl methacrylate	80-62-6
37.	Methacrylonitrile	126-98-7
38.	Methylene chloride	75-09-2
230.	2-Nitropropane	79-46-9
39.	Pyridine	110-86-1
40.	1,1,1,2-Tetrachloroethane	630-20-6
41.	1,1,2,2-Tetrachloroethane	79-34-6
42.	Tetrachloroethene	127-18-4
43.	Toluene	108-88-3
44.	Tribromomethane	75-25-2
45.	1,1,1-Trichloroethane	71-55-6
46.	1,1,2-Trichloroethane	79-00-5
47.	Trichloroethene	79-01-6
48.	Trichloromonofluoromethane	75-69-4
49.	1,2,3-Trichloropropane	96-18-4
231.	1,1,2-Trichloro 1,2,2-trifluoroethane	76-13-1
50.	Vinyl chloride	75-01-4
215.	1,2-Xylene	97-47-6
216.	1,3-Xylene	108-38-3
217.	1,4 Xylene	106-44-5
	Semivolatile organics	
51.	Acenaphthalene	208-96-8
52.	Acenaphthene	83-32-9
53.	Acetophenone	96-86-2
54.	2-Acetylaminofluorene	53-96-3
55.	4-Aminobiphenyl	92-67-1
56.	Aniline	62-53-3
57.	Anthracene	120-12-7
58.	Aramite	140-57-8
59.	Benz(a)anthracene	56-55-3
218.	Benzal chloride	98-87-3
60.	Benzenethiol	108-98-5
61.	Deleted	
62.	Benzo(a)pyrene	50-32-8
63.	Benzo(b)fluoranthene	205-99-2
64.	Benzo(ghi)perylene	191-24-2
65.	Benzo(k)fluoranthene	207-08-9
66.	p-Benzoquinone	106-51-4

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
67.	Bis(2-chloroethoxy)methane	111-91-1
68.	Bis(2-chloroethyl)ether	111-44-4
69.	Bis(2-chloroisopropyl)ether	39638-32-9
70.	Bis(2-ethylhexyl)phthalate	117-81-7
71.	4-Bromophenyl phenyl ether	101-55-3
72.	Butyl benzyl phthalate	85-68-7
73.	2-sec-Butyl-4,6-dinitrophenol	88-85-7
74.	p-Chloroaniline	106-47-8
75.	Chlorobenzilate	510-15-6
76.	p-Chloro-m-cresol	59-50-7
77.	2-Chloronaphthalene	91-58-7
78.	2-Chlorophenol	95-57-8
79.	3-Chloropropionitrile	542-76-7
80.	Chrysene	218-01-9
81.	ortho-Cresol	95-48-7
82.	para-Cresol	106-44-5
232.	Cyclohexanone	108 94 1
83.	Dibenz(a,h)anthracene	53-70-3
84.	Dibenzo(a,e)pyrene	192-65-4
85.	Dibenzo(a,i)pyrene	189-55-9
86.	m Dichlorobenzene	541 73 1
87.	o-Dichlorobenzene	95-50-1
88.	p-Dichlorobenzene	106-46-7
89.	3,3'-Dichlorobenzidine	91-94-1
90.	2,4 Dichlorophenol	120-83 2
91.	2,6-Dichlorophenol	87-65-0
92.	Diethyl phthalate	84-66-2
93.	3,3'-Dimethoxybenzidine	119-90-4
94.	p Dimethylaminoazobenzene	60-11-7
95.	3,3'-Dimethylbenzidine	119-93-7
96.	2,4-Dimethylphenol	105-67-9
97.	Dimethyl phthalate	131-11-3
98.	Di-n-butyl phthalate	84-74-2
99.	1,4-Dinitrobenzene	100-25-4
100.	4,6-Dinitro-o-cresol	534-52-1
101.	2,4-Dinitrophenol	51-28-5
102.	2,4-Dinitrotoluene	121-14-2
103.	2,6-Dinitrotoluene	606-20-2
104.	Di-n-octyl phthalate	117-84-0
105.	Di-n-propylnitrosamine	621-64-7
106.	Diphenylamine	122-39-4
219.	Diphenylnitrosamine	86-30-6

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
107.	1,2-Diphenylhydrazine	122-66-7
108.	Fluoranthene	206-44-0
109.	Fluorene	86-73-7
110.	Hexachlorobenzene	118-74-1
111.	Hexachlorobutadiene	87-68-3
112.	Hexachlorocyclopentadiene	77-47-4
113.	Hexachloroethane	67-72-1
114.	Hexachlorophene	70-30-4
115.	Hexachloropropene	1888-71-7
116.	Indeno(1,2,3-cd)pyrene	193-39-5
117.	Isosafrole	120-58-1
118.	Methapyrilene	91-80-5
119.	3 Methylcholanthrene	56 49-5
120.	4,4'-Methylenebis (2-chloroaniline)	101-14-4
36.	Methyl methanesulfonate	66-27-3
121.	Naphthalene	91-20-3
122.	1,4-Naphthoquinone	130-15-4
123.	1-Naphthylamine	134-32-7
124.	2-Naphthylamine	91-59-8
125.	p-Nitroaniline	100 01 6
126.	Nitrobenzene	98-95-3
127.	4-Nitrophenol	100-02-7
128.	N-Nitrosodi-n-butylamine	924-16-3
129.	N-Nitrosodiethylamine	55-18-5
130.	N-Nitrosodimethylamine	62-75-9
131.	N-Nitrosomethylethylamine	10595-95-6
132.	N-Nitrosomorpholine	59-89-2
133.	N-Nitrosopiperidine	100-75-4
134.	N-Nitrosopyrrolidine	930-55-2
135.	5-Nitro-o-toluidine	99-65-8
136.	Pentachlorobenzene	608 93-5
137.	Pentachloroethane	76-01-7
138.	Pentachloronitrobenzene	82-68-8
139.	Pentachlorophenol	87-86-5
140.	Phenacetin	62-44-2
141.	Phenanthrene	85-01-8
142.	Phenol	108-95-2
220.	Phthalic anhydride	85-44-9
143.	2-Picoline	109-06-8
144.	Pronamide	23950-58-5
145.	Pyrene	129-00-0
146.	Resorcinol	108-46-3

Table 1 1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
147.	Safrole	94-59-7
148.	1,2,4,5-Tetrachlorobenzene	95-94-3
149.	2,3,4,6-Tetrachlorophenol	58-90-2
150.	1,2,4-Trichlorobenzene	120-82-1
151.	2,4,5-Trichlorophenol	95-95-4
152.	2,4,6-Trichlorophenol	88-06-2
153.	Tris(2,3-dibromopropyl) phosphate	126-72-7
	Metals	
154.	Antimony	7440-36-0
155.	Arsenic	7440-38-2
156.	Barium	7440-39-3
157.	Beryllium	7440-41-7
158.	Cadmium	7440-43-9
159.	Chromium (total)	7440-47-3
221.	Chromium (hexavalent)	-
160.	Copper	7440-50-8
161.	Lead	7439-92-1
162.	Mercury	7439-97-6
163.	Nickel	7440-02-0
164.	Selenium	7782-49-2
165.	Silver	7440-22-4
166.	Thallium	7440-28-0
167.	Vanadium	7440-62-2
168.	Zinc	7440-66-6
	Inorganics other than metals	
169.	Cyanide	57-12-5
170.	Fluoride	16964-48-8
171.	Sulfide	8496-25-8
	Organochlorine pesticides	
172.	Aldrin	309-00-2
173.	alpha-BHC	319-84-6
174.	beta-BHC	319-85-7
175.	delta-BHC	319-86-8

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Organochlorine pesticides (continued)	
176.	gamma-BHC	58-89-9
177.	Chlordane	57-74-9
178.	DDD	72-54-8
179.	DDE	72-55-9
180.	DDT	50-29-3
181.	Dieldrin	60-57-1
182.	Endosulfan I	939-98-8
183.	Endosulfan II	33213-6-5
184.	Endrin	72-20-8
185.	Endrin aldehyde	7421-93-4
186.	Heptachlor	76-44-8
187.	Heptachlor epoxide	1024-57-3
188.	Isodrin	465-73-6
189.	Kepone	143-50-0
190.	Methoxyclor	72-43-5
191.	Toxaphene	8001-35-2
	Phenoxyacetic acid herbicides	
192.	2,4-Dichlorophenoxyacetic acid	94-75-7
193.	Silvex	93-72-1
194.	2,4,5-T	93-76-5
	Organophosphorous insecticides	
195.	Disulfoton	298-04-4
196.	Famphur	52-85-7
197.	Methyl parathion	298-00-0
198.	Parathion	56-38-2
199.	Phorate	298-02-2
	PCBs	
200.	Aroclor 1016	12674-11-2
201.	Aroclor 1221	11104-28-2
202.	Aroclor 1232	11141-16-5
203.	Aroclor 1242	53469-21-9
204.	Aroclor 1248	12672-29-6
205.	Aroclor 1254	11097-69-1
206.	Aroclor 1260	11096-82-5

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Dioxins and furans	
207.	Hexachlorodibenzo-p-dioxins	-
208.	Hexachlorodibenzofurans	-
209.	Pentachlorodibenzo-p-dioxins	-
210.	Pentachlorodibenzofurans	-
211.	Tetrachlorodibenzo-p-dioxins	-
212.	Tetrachlorodibenzofurans	-
213.	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6

comprehensive list of hazardous constituents specifically regulated under RCRA. The BDAT list consists of those constituents that can be analyzed using methods published in SW-846, Third Edition.

The initial BDAT constituent list was published in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT") in March 1987. Additional constituents are added to the BDAT constituent list as more key constituents are identified for specific waste codes or as new analytical methods are developed for hazardous constituents. For example, since the list was published in March 1987, 18 additional constituents (hexavalent chromium, xylenes (all three isomers), benzal chloride, phthalic anhydride, ethylene oxide, acetone, n-butyl alcohol, 2-ethoxyethanol, ethyl acetate, ethyl benzene, ethyl ether, methanol, methyl isobutyl ketone, 2-nitropropane, 1,1,2-trichloro-1,2,2-trifluoroethane, and cyclohexanone) have been added to the list.

Chemicals are listed in Appendix VIII if they are shown in scientific studies to have toxic, carcinogenic, mutagenic, or teratogenic effects on humans or other life-forms, and they include such substances as those identified by the Agency's Carcinogen Assessment Group as being carcinogenic. A waste can be listed as a toxic waste on the basis that it contains a constituent in Appendix VIII.

Although Appendix VII, Appendix VIII, and the F003 and F005 ignitables provide a comprehensive list of RCRA-regulated hazardous constituents, not all of the constituents can be analyzed in a complex waste matrix. Therefore, constituents that could not be readily analyzed in an unknown waste matrix were not included on the initial BDAT constituent list. As mentioned above, however, the BDAT constituent list is a continuously growing list that does not preclude the addition of new constituents when analytical methods are developed.

There are five major reasons that constituents were not included on the BDAT constituent list:

1. Constituents are unstable. Based on their chemical structure, some constituents will either decompose in water or will ionize. For example, maleic anhydride will form maleic acid when it comes in contact with water, and copper cyanide will ionize to form copper and cyanide ions. However, EPA may choose to regulate the decomposition or ionization products.

2. EPA-approved or verified analytical methods are not available. Many constituents, such as 1,3,5-trinitrobenzene, are not measured adequately or even detected using any of EPA's analytical methods published in SW-846 Third Edition.

3. The constituent is a member of a chemical group designated in Appendix VIII as not otherwise specified (N.O.S.). Constituents listed as N.O.S., such as chlorinated phenols, are a generic group of some types of chemicals for which a single analytical procedure is not available. The individual members of each such group need to be listed to determine whether the constituents can be analyzed. For each N.O.S. group, all those constituents that can be readily analyzed are included in the BDAT constituent list.

4. Available analytical procedures are not appropriate for a complex waste matrix. Some compounds, such as auramine, can be analyzed as a pure constituent. However, in the presence of other constituents, the recommended analytical method does not positively identify the constituent. The use of high performance liquid chromatography (HPLC) presupposes a high expectation of finding the specific constituents of interest. In using this procedure to screen samples, protocols would have to be developed on a case-specific basis to verify the identity of constituents present in the samples. Therefore, HPLC is usually not an appropriate analytical procedure for complex samples containing unknown constituents.

5. Standards for analytical instrument calibration are not commercially available. For several constituents, such as benz(c)acridine, commercially available standards of a "reasonably" pure grade are not available. The unavailability of a standard was determined by a review of catalogs from specialty chemical manufacturers.

Two constituents (fluoride and sulfide) are not specifically included in Appendices VII and VIII; however, these compounds are included on the BDAT list as indicator constituents for compounds from Appendices VII and VIII such as hydrogen fluoride and hydrogen sulfide, which ionize in water.

The BDAT constituent list presented in Table 1-1 is divided into the following nine groups:

- Volatile organics;
- Semivolatile organics;
- Metals;
- Other inorganics;
- Organochlorine pesticides;
- Phenoxyacetic acid herbicides;
- Organophosphorous insecticides;
- PCBs; and
- Dioxins and furans.

The constituents were placed in these categories based on their chemical properties. The constituents in each group are expected to behave similarly during treatment and are also analyzed, with the exception of the metals and the other inorganics, by using the same analytical methods.

(2) Constituent selection analysis. The constituents that the Agency selects for regulation in each waste are, in general, those found in the untreated wastes at treatable concentrations. For certain waste

codes, the target list for the untreated waste may have been shortened (relative to analyses performed to test treatment technologies) because of the extreme unlikelihood that the constituent will be present.

In selecting constituents for regulation, the first step is to develop of list of potentially regulated constituents by summarizing all the constituents that are present or are likely to be present in the untreated waste at treatable concentrations. A constituent is considered present in a waste if the constituent (1) is detected in the untreated waste above the detection limit, (2) is detected in any of the treated residuals above the detection limit, or (3) is likely to be present based on the Agency's analyses of the waste-generating process. In case (2), the presence of other constituents in the untreated waste may interfere with the quantification of the constituent of concern, making the detection limit relatively high and resulting in a finding of "not detected" when, in fact, the constituent is present in the waste. Thus, the Agency reserves the right to regulate such constituents.

After developing a list of potential constituents for regulation. EPA reviews this list to determine if any of these constituents can be excluded from regulation because they would be controlled by regulation of other constituents on the list. This indicator analysis is done for two reasons: (1) it reduces the analytical cost burdens on the treater and (2) it facilitates implementation of the compliance and enforcement program. EPA's rationale for selection of regulated constituents for this waste code is presented in Section 6 of this background document.

(3) Calculation of standards. The final step in the calculation of the BDAT treatment standard is the multiplication of the average accuracy-corrected treatment value by a factor referred to by the Agency as the variability factor. This calculation takes into account that even well-designed and well-operated treatment systems will experience some fluctuations in performance. EPA expects that fluctuations will result from inherent mechanical limitations in treatment control systems, collection of treated samples, and analysis of these samples. All of the above fluctuations can be expected to occur at well-designed and well-operated treatment facilities. Therefore, setting treatment standards utilizing a variability factor should be viewed not as a relaxing of section 3004(m) requirements, but rather as a function of the normal variability of the treatment processes. A treatment facility will have to be designed to meet the mean achievable treatment performance level to ensure that the performance levels remain within the limits of the treatment standard.

The Agency calculates a variability factor for each constituent of concern within a waste treatability group using the statistical calculation presented in Appendix A. The equation for calculating the variability factor is the same as that used by EPA for the development of numerous regulations in the Effluent Guidelines Program under the Clean Water Act. The variability factor establishes the instantaneous maximum based on the 99th percentile value.

There is an additional step in the calculation of the treatment standards in those instances where the ANOVA analysis shows that more than one technology achieves a level of performance that represents BDAT. In such instances, the BDAT treatment standard for each constituent of concern is calculated by first averaging the mean performance value for each technology and then multiplying that value by the highest variability factor among the technologies considered. This procedure ensures that all the technologies used as the basis for the BDAT treatment standards will achieve full compliance.

1.2.5 Compliance with Performance Standards

Usually the treatment standards reflect performance achieved by the best demonstrated available technology (BDAT). As such, compliance with these numerical standards requires only that the treatment level be achieved prior to land disposal. It does not require the use of any particular treatment technology. While dilution of the waste as a means to comply with the standards is prohibited, wastes that are generated in such a way as to naturally meet the standards can be land disposed without treatment. With the exception of treatment standards that prohibit land disposal or that specify use of certain treatment methods, all established treatment standards are expressed as concentration levels.

EPA is using both the total constituent concentration and the concentration of the constituent in the TCLP extract of the treated waste as a measure of technology performance.

For all organic constituents, EPA is basing the treatment standards on the total constituent concentration found in the treated waste. EPA is using this measurement because most technologies for treatment of organics destroy or remove organics compounds. Accordingly, the best measure of performance would be the total amount of constituent remaining after treatment. (NOTE: EPA's land disposal restrictions for solvent waste codes F001-F005 (51 FR 40572) use the TCLP extract value as a measure of performance. At the time that EPA promulgated the treatment standards for F001-F005, useful data were not available on total constituent concentrations in treated residuals, and, as a result, the TCLP data were considered to be the best measure of performance.)

For all metal constituents, EPA is using both total constituent concentration and/or the TCLP extract concentration as the basis for treatment standards. The total constituent concentration is being used when the technology basis includes a metal recovery operation. The underlying principle of metal recovery is that it reduces the amount of metal in a waste by separating the metal for recovery; total constituent concentration in the treated residual, therefore, is an important measure of performance for this technology. Additionally, EPA also believes that it is important that any remaining metal in a treated residual waste not be in a state that is easily leachable; accordingly, EPA is also using the TCLP extract concentration as a measure of performance. It is important to note that for wastes for which treatment standards are based on a metal recovery process, the facility has to comply with both the total and the TCLP extract constituent concentrations prior to land disposing the waste.

In cases where treatment standards for metals are not based on recovery techniques but rather on stabilization, EPA is using only the TCLP value as a measure of performance. The Agency's rationale is that stabilization is not meant to reduce the concentration of metal in a waste but only to chemically minimize the ability of the metal to leach.

1.2.6 Identification of BDAT

BDAT for a waste must be the "best" of the demonstrated available technologies. EPA determines which technology constitutes "best" after screening the available data from each demonstrated technology, adjusting these data for accuracy, and comparing the performance of each demonstrated technology to that of the others. If only one technology is identified as demonstrated, it is considered "best"; if it is available, the technology is BDAT.

(1) Screening of treatment data. The first activity in determining which of the treatment technologies represent treatment by BDAT is to screen the treatment performance data from each of the demonstrated and available technologies according to the following criteria:

1. Design and operating data associated with the treatment data must reflect a well-designed, well-operated system for each treatment data point. (The specific design and operating parameters for each demonstrated technology for the waste code(s) of interest are discussed in Section 3.2 of this document.)

2. Sufficient QA/QC data must be available to determine the true values of the data from the treated waste. This screening criterion involves adjustment of treated data to take into account that the true value may be different from the measured value. This discrepancy generally is caused by other constituents in the waste that can mask results or otherwise interfere with the analysis of the constituent of concern.

3. The measure of performance must be consistent with EPA's approach to evaluating treatment by type of constituents (e.g., total concentration data for organics, and total concentration and TCLP extract concentration for metals from the residual).

In the absence of data needed to perform the screening analysis, EPA will make decisions on a case-by-case basis as to whether to use the data as a basis for the treatment standards. The factors included in this case-by-case analysis will be the actual treatment levels achieved, the availability of the treatment data and their completeness (with respect to the above criteria), and EPA's assessment of whether the untreated waste represents the waste code of concern.

(2) Comparison of treatment data. In cases in which EPA has treatment data from more than one demonstrated available technology following the screening activity, EPA uses the statistical method known as analysis of variance (ANOVA) to determine if one technology performs significantly better than the others. This statistical method (summarized in Appendix A) provides a measure of the differences between two data sets. Specifically, EPA uses the analysis of variance to determine whether BDAT represents a level of performance achieved by only one technology or represents a level of performance achieved by more than one (or all) of the technologies. If EPA finds that one technology performs significantly better (i.e., is "best"), BDAT treatment standards

are the level of performance achieved by that best technology multiplied by the corresponding variability factor for each regulated constituent. If the Agency finds that the levels of performance for one or more technologies are not statistically different, EPA averages the performance values achieved by each technology and then multiplies this value by the largest variability factor associated with any of the technologies.

(3) Quality assurance/quality control. This section presents the principal quality assurance/quality control (QA/QC) procedures employed in screening and adjusting the data to be used in the calculation of treatment standards. Additional QA/QC procedures used in collecting and screening data for the BDAT program are presented in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-87-011.

To calculate the treatment standards for the land disposal restriction rules, it is first necessary to determine the recovery value for each constituent (the amount of constituent recovered after spiking--which is the addition of a known amount of the constituent--minus the initial concentration in the samples, all divided by the spike amount added) for each spiked sample of the treated residual. Once the recovery values are determined, the following procedures are used to select the appropriate percent recovery value to adjust the analytical data:

1. If duplicate spike recovery values are available for the constituent of interest, the data are adjusted by the lowest available percent recovery value (i.e., the value that will yield the most conservative estimate of treatment achieved). However, if a spike recovery value of less than 20 percent is reported for a specific constituent, the data are not used to set treatment standards because the Agency does not have sufficient confidence in the reported value to set a national standard.

2. If data are not available for a specific constituent but are available for an isomer, then the spike recovery data are transferred from the isomer and the data are adjusted using the percent recovery selected according to the procedure described in (1) above.

3. If data are not available for a specific constituent but are available for a similar class of constituents (e.g., volatile organics, acid-extractable semivolatiles), then spike recovery data available for this class of constituents are transferred. All spike recovery values greater than or equal to 20 percent for a spike sample are averaged and the constituent concentration is adjusted by the average recovery value. If spiked recovery data are available for more than one sample, the average is calculated for each sample and the data are adjusted by using the lowest average value.

4. If matrix spike recovery data are not available for a set of data to be used to calculate treatment standards, then matrix spike recovery data are transferred from a waste that the Agency believes is similar (e.g., if the data represent an ash from incineration, then data from other incinerator ashes could be used). While EPA recognizes that transfer of matrix spike recovery data from a similar waste is not an exact analysis, this is considered the best approach for adjusting the data to account for the fact that most analyses do not result in extraction of 100 percent of the constituent. In assessing the recovery data to be transferred, the procedures outlined in (1), (2), and (3) above are followed.

The analytical procedures employed to generate the data used to calculate the treatment standards are listed in Appendix B of this document. In cases where alternatives or equivalent procedures and/or equipment are allowed in EPA's SW-846, Third Edition methods, the specific procedures and equipment used are documented. In addition, any deviations from the SW-846, Third Edition methods used to analyze the specific waste matrices are documented. It is important to note that the Agency will use the methods and procedures delineated in Appendix B to enforce the treatment standards presented in Section 7 of this document. Accordingly, facilities should use these procedures in assessing the performance of their treatment systems.

1.2.7 BDAT Treatment Standards for "Derived-From" and "Mixed" Wastes

(1) Wastes from treatment trains generating multiple residues. In a number of instances, the proposed BDAT consists of a series of operations, each of which generates a waste residue. For example, the proposed BDAT for a certain waste code is based on solvent extraction, steam stripping, and activated carbon adsorption. Each of these treatment steps generates a waste requiring treatment--a solvent-containing stream from solvent extraction, a stripper overhead, and spent activated carbon. Treatment of these wastes may generate further residues; for instance, spent activated carbon (if not regenerated) could be incinerated, generating an ash and possibly a scrubber water waste. Ultimately, additional wastes are generated that may require land disposal. With respect to these wastes, the Agency wishes to emphasize the following points:

1. All of the residues from treating the original listed wastes are likewise considered to be the listed waste by virtue of the derived-from rule contained in 40 CFR 261.3(c)(2). (This point is discussed more fully in (2) below.) Consequently, all of the wastes generated in the course of treatment would be prohibited from land disposal unless they satisfy the treatment standard or meet one of the exceptions to the prohibition.

2. The Agency's proposed treatment standards generally contain a concentration level for wastewaters and a concentration level for nonwastewaters. The treatment standards apply to all of the wastes generated in treating the original prohibited waste. Thus, all derived-from wastes meeting the Agency definition of wastewater (less than 1 percent total organic carbon (TOC) and less than 1 percent total suspended solids) would have to meet the treatment standard for wastewaters. All residuals not meeting this definition would have to meet the treatment standard for nonwastewaters. EPA wishes to make clear that this approach is not meant to allow partial treatment in order to comply with the applicable standard.

3. The Agency has not performed tests, in all cases, on every waste that can result from every part of the treatment train. However, the Agency's treatment standards are based on treatment of the most concentrated form of the waste. Consequently, the Agency believes that the less concentrated wastes generated in the course of treatment will also be able to be treated to meet this value.

(2) Mixtures and other derived-from residues. There is a further question as to the applicability of the BDAT treatment standards to residues generated not from treating the waste (as discussed above), but from other types of management. Examples are contaminated soil or leachate that is derived from managing the waste. In these cases, the mixture is still deemed to be the listed waste, either because of the derived-from rule (40 CFR 261.3(c)(2)(i)) or the mixture rule (40 CFR 261.3(a)(2)(iii) and (iv)) or because the listed waste is contained in the matrix (see, for example, 40 CFR 261.33(d)). The prohibition for the particular listed waste consequently applies to this type of waste.

The Agency believes that the majority of these types of residues can meet the treatment standards for the underlying listed wastes (with the possible exception of contaminated soil and debris for which the Agency is currently investigating whether it is appropriate to establish a separate treatability subcategorization). For the most part, these residues will be less concentrated than the original listed waste. The Agency's treatment standards also make a generous allowance for process variability by assuming that all treatability values used to establish the standard are lognormally distributed. The waste also might be amenable to a relatively nonvariable form of treatment technology such as incineration. Finally, and perhaps most important, the rules contain a treatability variance that allows a petitioner to demonstrate that its waste cannot be treated to the level specified in the rule (40 CFR Part 268.44(a)). This provision provides a safety valve that allows persons with unusual waste matrices to demonstrate the appropriateness of a different standard. The Agency, to date, has not received any petitions under this provision (for example, for residues contaminated with a prohibited solvent waste), indicating, in the Agency's view, that the existing standards are generally achievable.

(3) Residues from managing listed wastes or that contain listed wastes. The Agency has been asked if and when residues from managing hazardous wastes, such as leachate and contaminated ground water, become subject to the land disposal prohibitions. Although the Agency believes this question to be settled by existing rules and interpretative statements, to avoid any possible confusion the Agency will address the question again.

Residues from managing First Third wastes, listed California List wastes, and spent solvent and dioxin wastes are all considered to be subject to the prohibitions for the listed hazardous waste as originally generated. Residues from managing California List wastes likewise are subject to the California List prohibitions when the residues themselves exhibit a characteristic of hazardous waste. This determination stems directly from the derived-from rule in 40 CFR 261.3(c)(2) or, in some cases, from the fact that the waste is mixed with or otherwise contains the listed waste. The underlying principle stated in all of these provisions is that listed wastes remain listed until delisted.

The Agency's historic practice in processing delisting petitions that address mixing residuals has been to consider them to be the listed waste and to require that delisting petitioners address all constituents for which the derived-from waste (or other mixed waste) was listed. The language in 40 CFR 260.22(b) states that mixtures or derived-from residues can be delisted provided a delisting petitioner makes a demonstration identical to that which a delisting petitioner would make for the original listed waste. Consequently, these residues are treated as the original listed waste for delisting purposes. The statute likewise takes this position, indicating that soil and debris that are contaminated with listed spent solvents or dioxin wastes are subject to the prohibition for these wastes even though these wastes are not the originally generated waste, but rather are a residual from management (RCRA section 3004(e)(3)). It is EPA's view that all such residues are covered by the existing prohibitions and treatment standards for the listed hazardous waste that these residues contain or from which they are derived.

1.2.8 Transfer of Treatment Standards

EPA is proposing some treatment standards that are not based on testing of the treatment technology on the specific waste subject to the treatment standard. The Agency has determined that the constituents present in the untested waste can be treated to the same performance levels as those observed in other wastes for which EPA has previously developed treatment data. EPA believes that transferring treatment performance data for use in establishing treatment standards for untested wastes is technically valid in cases where the untested wastes are generated from similar industries or processing steps, or have similar waste characteristics affecting performance and treatment selection. Transfer of treatment standards to similar wastes or wastes from similar processing steps requires little formal analysis. However, in a case where only the industry is similar, EPA more closely examines the waste characteristics prior to deciding whether the untested waste constituents can be treated to levels associated with tested wastes.

EPA undertakes a two-step analysis when determining whether constituents in the untested wastes can be treated to the same level of performance as in the tested waste. First, EPA reviews the available waste characterization data to identify those parameters that are expected to affect treatment selection. EPA has identified some of the most important constituents and other parameters needed to select the treatment technology appropriate for the given waste(s) in Section 3.

Second, when analysis suggests that an untested waste can be treated with the same technology as a waste for which treatment performance data are already available, EPA analyzes a more detailed list of characteristics that the Agency believes will affect the performance of the technology. By examining and comparing these characteristics, the Agency determines whether the untested wastes will achieve the same level of treatment as the tested waste. Where the Agency determines that the untested waste can be treated as well or better than the tested waste, the treatment standards can be transferred.

1.3 Variance from the BDAT Treatment Standard

The Agency recognizes that there may exist unique wastes that cannot be treated to the level specified as the treatment standard. In such a case, a generator or owner/operator may submit a petition to the Administrator requesting a variance from the treatment standard. A particular waste may be significantly different from the wastes on which the treatment standards are based because the subject waste contains a more complex matrix that makes it more difficult to treat. For example, complex mixtures may be formed when a restricted waste is mixed with other waste streams by spills or other forms of inadvertent mixing. As a result, the treatability of the restricted waste may be altered such that it cannot meet the applicable treatment standard.

Variance petitions must demonstrate that the treatment standard established for a given waste cannot be met. This demonstration can be made by showing that attempts to treat the waste by available technologies were not successful or by performing appropriate analyses of the waste, including waste characteristics affecting performance, which demonstrate that the waste cannot be treated to the specified levels. Variances will not be granted based solely on a showing that adequate BDAT treatment capacity is unavailable. (Such demonstrations can be made according to the provisions in Part 268.5 of RCRA for case-by-case extensions of the effective date.) The Agency will consider granting generic petitions provided that representative data are submitted to support a variance for each facility covered by the petition.

Petitioners should submit at least one copy to:

The Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

An additional copy marked "Treatability Variance" should be submitted to:

Chief, Waste Treatment Branch
Office of Solid Waste (WH-565)
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Petitions containing confidential information should be sent with only the inner envelope marked "Treatability Variance" and "Confidential Business Information" and with the contents marked in accordance with the requirements of 40 CFR Part 2 (41 FR 36902, September 1, 1976, amended by 43 FR 4000).

The petition should contain the following information:

1. The petitioner's name and address.
2. A statement of the petitioner's interest in the proposed action.
3. The name, address, and EPA identification number of the facility generating the waste, and the name and telephone number of the plant contact.
4. The process(es) and feed materials generating the waste and an assessment of whether such process(es) or feed materials may produce a waste that is not covered by the demonstration.
5. A description of the waste sufficient for comparison with the waste considered by the Agency in developing BDAT, and an estimate of the average and maximum monthly and annual quantities of waste covered by the demonstration. (Note: The petitioner should consult the appropriate BDAT background document for determining the characteristics of the wastes considered in developing treatment standards.)
6. If the waste has been treated, a description of the system used for treating the waste, including the process design and operating conditions. The petition should include the reasons the treatment standards are not achievable and/or why the petitioner believes the standards are based on inappropriate technology for treating the waste. (Note: The petitioner should refer to the BDAT background document as guidance for determining the design and operating parameters that the Agency used in developing treatment standards.)
7. A description of the alternative treatment systems examined by the petitioner (if any); a description of the treatment system deemed appropriate by the petitioner for the waste in question; and, as appropriate, the concentrations in the treatment residual or extract of the treatment residual (i.e., using the TCLP, where appropriate, for stabilized metals) that can be achieved by applying such treatment to the waste.
8. A description of those parameters affecting treatment selection and waste characteristics that affect performance, including results of all analyses. (See Section 3 for a discussion of

waste characteristics affecting performance that the Agency has identified for the technology representing BDAT.)

9. The dates of the sampling and testing.
10. A description of the methodologies and equipment used to obtain representative samples.
11. A description of the sample handling and preparation techniques, including techniques used for extraction, containerization, and preservation of the samples.
12. A description of analytical procedures used, including QA/QC methods.

After receiving a petition for a variance, the Administrator may request any additional information or waste samples that may be required to evaluate and process the petition. Additionally, all petitioners must certify that the information provided to the Agency is accurate under 40 CFR 268.4(b).

In determining whether a variance will be granted, the Agency will first look at the design and operation of the treatment system being used. If EPA determines that the technology and operation are consistent with BDAT, the Agency will evaluate the waste to determine if the waste matrix and/or physical parameters are such that the BDAT treatment standards reflect treatment of this waste. Essentially, this latter analysis will concern the parameters affecting treatment selection and waste characteristics affecting performance parameters.

In cases where BDAT is based on more than one technology, the petitioner will need to demonstrate that the treatment standard cannot be met using any of the technologies, or that none of the technologies are appropriate for treatment of the waste. After the Agency has made a determination on the petition, the Agency's findings will be published in the *Federal Register*, followed by a 30-day period for public comment. After review of the public comments, EPA will publish its final determination in the *Federal Register* as an amendment to the treatment standards in 40 CFR Part 268, Subpart D.

2. INDUSTRIES AFFECTED AND WASTE CHARACTERIZATION

The previous section discussed the BDAT program and the methodology used by the Agency to develop treatment standards. The purpose of this section is to describe the industries affected by the land disposal restrictions for K062 wastes, the processes generating the wastes, and the available waste characterization data for K062 wastes.

According to 40 CFR 261.32 (hazardous wastes from specific sources), the waste identified as K062 is spent pickle liquor generated by steel finishing operations of facilities within the iron and steel industry (Standard Industrial Classification (SIC) codes 331 and 332).

2.1 Industries Affected and Process Description

The listed waste K062 is generated by the steel industry from steel finishing operations. The Agency estimates that approximately 978 facilities have steel finishing operations that could generate the K062 waste. Tables 2-1 to 2-6 and Figure 2-1 present the location of these facilities by State and EPA region. The facilities that may generate spent pickle liquor (K062) from steel finishing operations are those that fall under the SIC codes 331 and 332.

In the steel industry, steel products are exposed to the atmosphere during forming and finishing operations, causing oxide scale to form on their surfaces. This scale must be removed prior to additional processing in order to prepare the surface for protective coatings and cold rolling. Acid pickling is the method used most widely by the steel industry to remove the oxide scale. In addition, the steel surface must

Table 2-1 Census Data (1982) for Number of Facilities in Each State and EPA Region

Blast Furnaces and Steel Mills[a]

State	Facilities	State	Facilities	EPA Region	Totals
AL (IV)	15	MT (VIII)		I	1
AK (X)		NE (VII)	1	II	26
AZ (IX)	1	NV (IX)		III	67
AR (VI)		NH (I)		IV	49
CA (IX)	19	NJ (II)	6	V	78
CO (VIII)	2	NM (VI)		VI	24
CT (I)	1	NY (II)	20	VII	2
DE (III)	1	NC (IV)	3	VIII	8
DC (III)		ND (VIII)		IX	20
FL (IV)	5	OH (V)	26	X	10
GA (IV)	4	OK (VI)	5		285
HI (IX)		OR (X)	5		
ID (X)		PA (III)	52		
IL (V)	19	RI (I)			
IN (V)	11	SC (IV)	5		
IA (VII)	1	SD (VIII)			
KS (VII)		TN (IV)	7		
KY (IV)	8	TX (VI)	14		
LA (VI)	5	UT (VIII)	2		
ME (I)		VT (I)			
MD (III)	3	VA (III)	7		
MA (I)		WA (X)	5		
MI (V)	15	WV (III)	4		
MN (V)	3	WI (V)	4		
MS (IV)	2	WY (VIII)			
MO (VIII)	4				

[a] Includes data for SIC code 3312 only.

Reference: U.S. Department of Commerce 1984.

Table 2-2 Census Data (1982) for Number of Facilities
in Each State and EPA Region

Electrometallurgical Products[a]

State	Facilities	State	Facilities	EPA Region	Totals
AL (IV)		MT (VIII)		I	
AK (X)		NE (VII)		II	3
AZ (IX)		NV (IX)		III	5
AR (VI)		NH (I)		IV	7
CA (IX)		NJ (II)	3	V	8
CO (VIII)		NM (VI)		VI	
CT (I)		NY (II)		VII	1
DE (III)		NC (IV)		VIII	
DC (III)		ND (VIII)		IX	
FL (IV)		OH (V)	8	X	2
GA (IV)		OK (VI)			26
HI (IX)		OR (X)	2		
ID (X)		PA (III)	1		
IL (V)		RI (I)			
IN (V)		SC (IV)	2		
IA (VII)	1	SD (VIII)			
KS (VII)		TN (IV)	4		
KY (IV)	1	TX (VI)			
LA (VI)		UT (VIII)			
ME (I)		VT (I)			
MD (III)		VA (III)			
MA (I)		WA (X)			
MI (V)		WV (III)	4		
MN (V)		WI (V)			
MS (IV)		WY (VIII)			
MO (VIII)					

[a] Includes data for SIC code 3313 only.

Reference: U.S. Department of Commerce 1984.

Table 2-3 Census Data (1982) for Number of Facilities in Each State and EPA Region

Steel Wire and Related Products[a]

State	Facilities	State	Facilities	EPA Region	Totals
AL (IV)	6	MT (VIII)		I	34
AK (X)		NE (VII)		II	31
AZ (IX)		NV (IX)		III	33
AR (VI)	2	NH (I)		IV	49
CA (IX)	34	NJ (II)	16	V	79
CO (VIII)		NM (VI)		VI	30
CT (I)	15	NY (II)	15	VII	
DE (III)	2	NC (IV)	5	VIII	7
DC (III)		ND (VIII)		IX	34
FL (IV)	13	OH (V)	21	X	
GA (IV)	6	OK (VI)	3		297
HI (IX)		OR (X)			
ID (X)		PA (III)	25		
IL (V)	30	RI (I)			
IN (V)	10	SC (IV)	6		
IA (VII)		SD (VIII)			
KS (VII)		TN (IV)	5		
KY (IV)	4	TX (VI)	22		
LA (VI)	3	UT (VIII)			
ME (I)		VT (I)			
MD (III)	4	VA (III)	2		
MA (I)	19	WA (X)			
MI (V)	12	WV (III)			
MN (V)	2	WI (V)	4		
MS (IV)	4	WY (VIII)			
MO (VIII)	7				

[a] Includes data for SIC code 3315 only.

Reference: U.S. Department of Commerce 1984.

Table 2-4 Census Data (1982) for Number of Facilities in Each State and EPA Region

Cold Finishing of Steel Shapes[a]

State	Facilities	State	Facilities	EPA Region	Totals
AL (IV)		MT (VIII)		I	4
AK (X)		NE (VII)		II	17
AZ (IX)		NV (IX)		III	25
AR (VI)		NH (I)		IV	6
CA (IX)	12	NJ (II)	9	V	76
CO (VIII)	10	NM (VI)		VI	10
CT (I)		NY (II)	8	VII	
DE (III)		NC (IV)		VIII	10
DC (III)		ND (VIII)		IX	12
FL (IV)		OH (V)	24	X	
GA (IV)		OK (VI)			160
HI (IX)		OR (X)			
ID (X)		PA (III)	23		
IL (V)	18	RI (I)			
IN (V)	7	SC (IV)			
IA (VII)		SD (VIII)			
KS (VII)		TN (IV)			
KY (IV)		TX (VI)	10		
LA (VI)		UT (VIII)			
ME (I)		VT (I)			
MD (III)	2	VA (III)			
MA (I)	4	WA (X)			
MI (V)	22	WV (III)			
MN (V)		WI (V)	5		
MS (IV)	6	WY (VIII)			
MO (VIII)					

[a] Includes data for SIC code 3316 only.

Reference: U.S. Department of Commerce 1984.

Table 2-5 Census Data (1982) for Number of Facilities in Each State and EPA Region

Steel Pile and Tubes[a]

State	Facilities	State	Facilities	EPA Region	Totals
AL (IV)	2	MT (VIII)		I	
AK (X)		NE (VII)		II	15
AZ (IX)		NV (IX)		III	31
AR (VI)	2	NH (I)		IV	14
CA (IX)	26	NJ (II)	8	V	93
CO (VIII)	3	NM (VI)		VI	22
CT (I)		NY (II)	7	VII	1
DE (III)		NC (IV)		VIII	7
DC (III)		ND (VIII)		IX	26
FL (IV)		OH (V)	26	X	1
GA (IV)	3	OK (VI)	5		210
HI (IX)		OR (X)			
ID (X)		PA (III)	27		
IL (V)	19	RI (I)			
IN (V)	13	SC (IV)			
IA (VII)	1	SD (VIII)			
KS (VII)		TN (IV)	6		
KY (IV)	3	TX (VI)	12		
LA (VI)	3	UT (VIII)			
ME (I)		VT (I)			
MD (III)	2	VA (III)			
MA (I)		WA (X)	1		
MI (V)	25	WV (III)	2		
MN (V)	3	WI (V)	7		
MS (IV)		WY (VIII)			
MO (VIII)	4				

[a] Includes data for SIC code 3317 only.

Reference: U.S. Department of Commerce 1984.

Table 2-6 Number of Facilities in Each EPA Region

EPA Region	Totals
I	39
II	92
III	161
IV	125
V	334
VI	86
VII	4
VIII	32
IX	92
X	13
	978

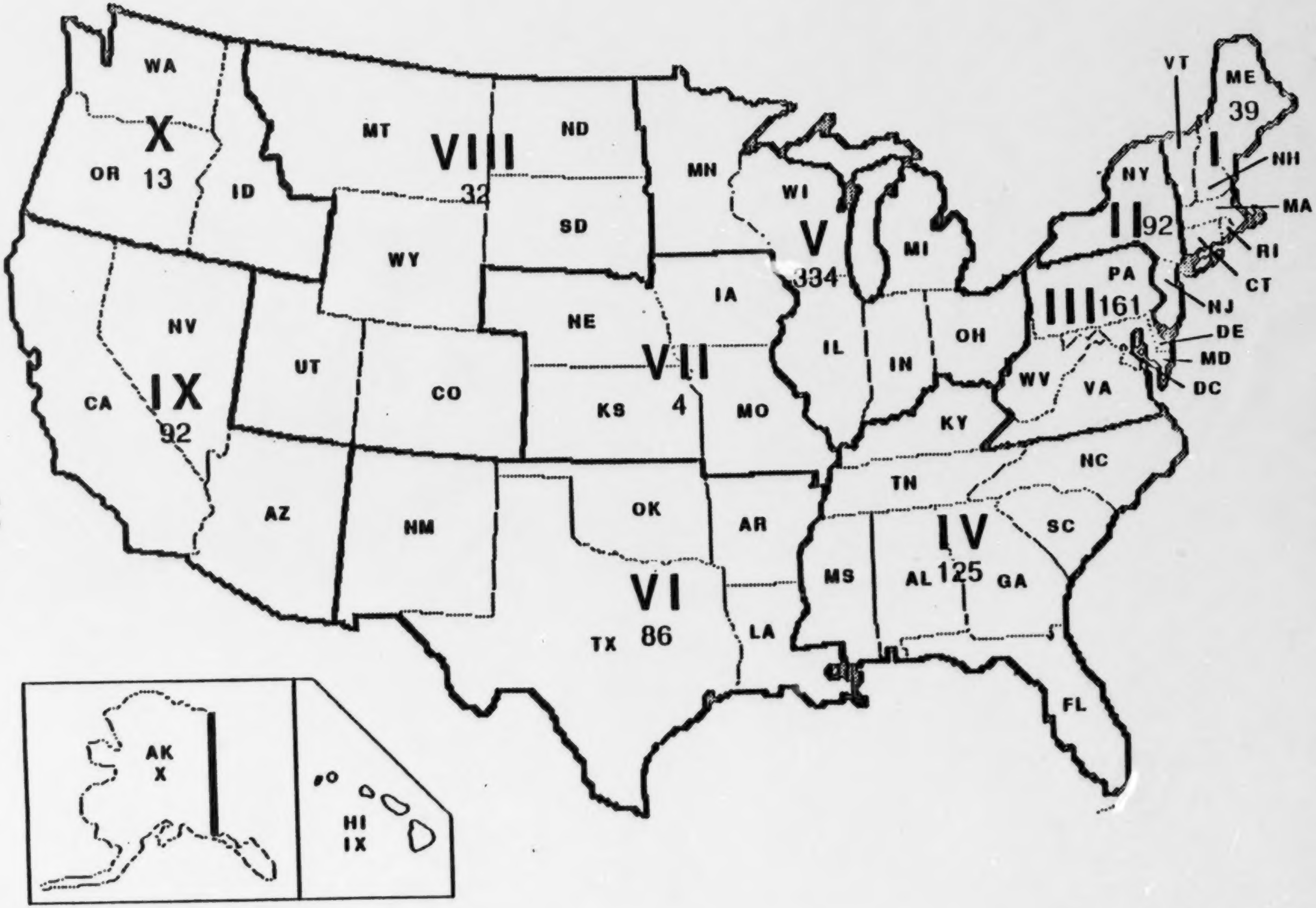

WA
X
OR 13
ID
MT
VIII
32
ND
SD
WY
MN
WI
V
334
MI
IA
NE
VII
4
IL
IN
OH
KS
MO
KY
CA
IX
92
NV
UT
CO
AZ
NM
OK
VI
86
TX
AR
LA
MS
AL
IV
125
GA
TN
NC
SC
FL
VT
ME
39
I
NH
MA
RI
CT
NY
II
92
PA
III
161
NJ
DE
MD
DC
WV
VA
AK
X
HI
IX

FIGURE 2-1 FACILITIES PRODUCING K062 WASTE BY EPA REGION

be cleaned (by pickling) at various stages throughout the steel production process to ensure that oxides forming on the surface are not worked into the finished product.

The pickling operation involves the immersion of the oxidized steel product into a heated solution of concentrated acid or acids (the pickling agent). There are generally three types of pickling agents: (1) sulfuric acid, (2) hydrochloric acid, and (3) combined acids. The type of pickling agent used in a finishing operation depends on the type of steel being processed and the surface quality desired. When a certain concentration of metal ions builds up in the pickling bath, the solution is considered spent and must be replaced. This spent pickle liquor is the listed waste K062.

Pickling is accomplished in either continuous (see Figure 2-2) or batch operations (see Figure 2-3):

- Continuous pickling. Continuous pickling is the method predominantly used for pickling steel products. As shown in Figure 2-2, steel products are continuously fed through a series of pickling tanks containing acid solution. The pickling solution flows in one direction, while the steel product travels in the opposite direction, i.e., countercurrent. A fresh acid solution is added to the last tank in a series of tanks and flows through the tanks to an overflow located in the first tank. The acid overflow from the first tank is the waste stream K062.

- Batch pickling. Batch operations typically utilize large, open tanks, holding the pickling agent. As shown in Figure 2-3, steel products are dipped in the pickling tank for the removal of scale. After continual use, the free acid content of the pickling tank decreases and the metal ion concentration increases. When the free acid level falls to a specified value or the metal ion concentration reaches a specified value, the pickling agent is considered spent and is dumped as a batch. This spent batch of pickling solution is K062 waste.

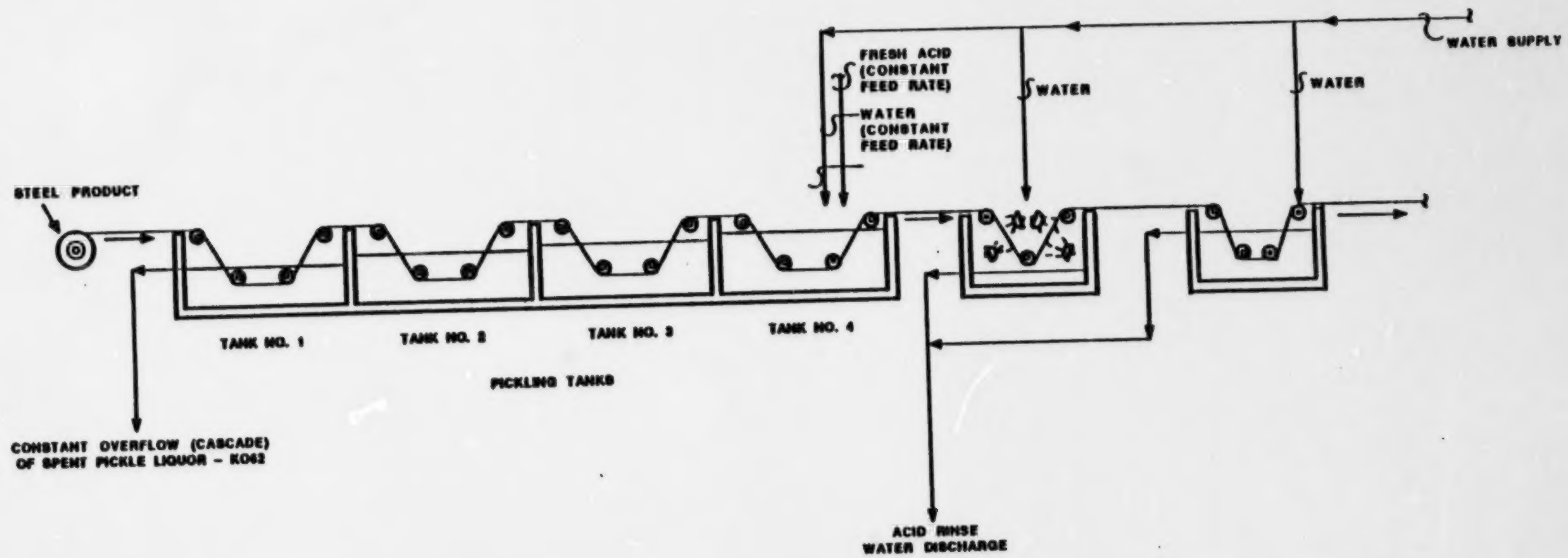

STEEL PRODUCT
TANK NO. 1
TANK NO. 2
TANK NO. 3
TANK NO. 4
PICKLING TANKS
CONSTANT OVERFLOW (CASCADE) OF SPENT PICKLE LIQUOR - KO62
FRESH ACID (CONSTANT FEED RATE)
WATER (CONSTANT FEED RATE)
WATER
WATER
WATER SUPPLY
ACID RINSE WATER DISCHARGE

FIGURE 2-2 EXAMPLE OF CONTINUOUS (COUNTERCURRENT) PICKLING PROCESS AND GENERATION OF KO62

REFERENCE: U.S. ENVIRONMENTAL PROTECTION AGENCY 1982.

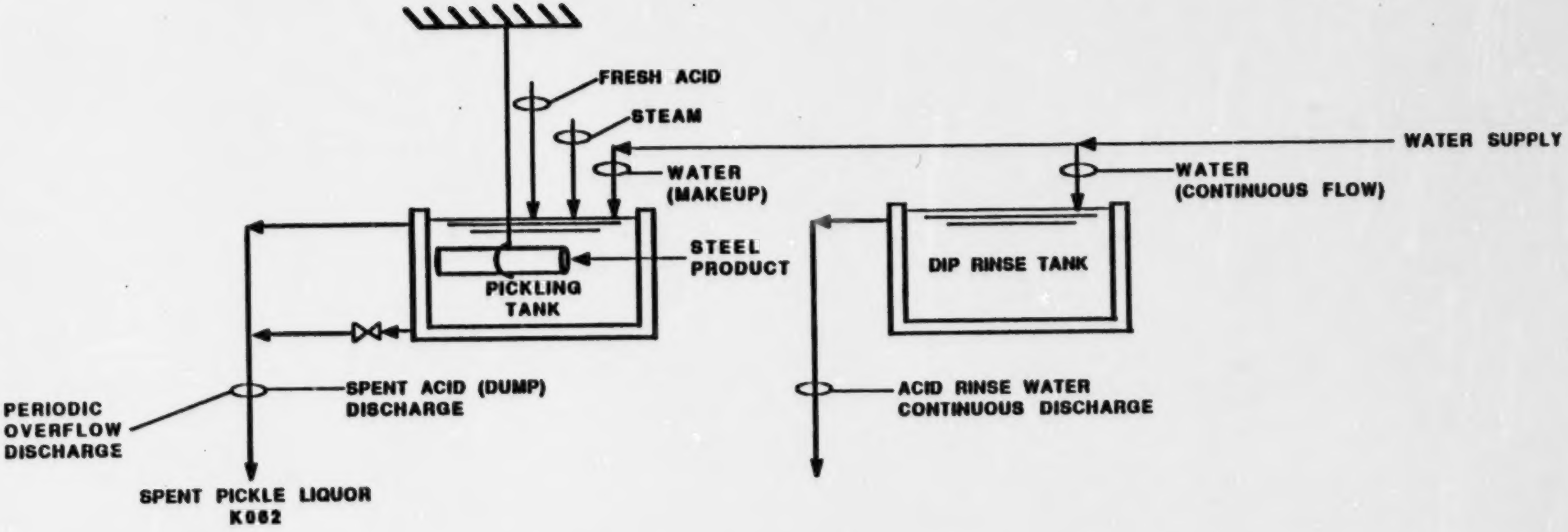

FRESH ACID
STEAM
WATER SUPPLY
WATER (MAKEUP)
WATER (CONTINUOUS FLOW)
STEEL PRODUCT
PICKLING TANK
DIP RINSE TANK
SPENT ACID (DUMP) DISCHARGE
ACID RINSE WATER CONTINUOUS DISCHARGE
PERIODIC OVERFLOW DISCHARGE
SPENT PICKLE LIQUOR K062

FIGURE 2-3 EXAMPLE OF BATCH PICKLING PROCESS AND GENERATION OF KO62

REFERENCE: U.S. ENVIRONMENTAL PROTECTION AGENCY 1982.

2.2 Waste Characterization

This section includes all of the waste characterization data available to the Agency for K062 wastes. Table 2-7 provides an estimate of the major constituents present in the waste, along with their approximate concentrations. The percent concentration of each major constituent in the waste was determined using engineering judgment based on chemical analyses. The Agency has obtained waste composition data from its own testing program and from numerous industry sources. BDAT list constituents had a concentration of approximately 1 percent, while water and other inorganics had concentrations of approximately 93 and 6 percent, respectively. The ranges of BDAT list constituents in the untreated waste are presented in Table 2-8. The constituents detected in the untreated K062 waste are BDAT list metals, namely, arsenic, chromium, copper, lead, nickel, and zinc. Chromium, copper, and nickel appear in the highest concentrations in the K062 waste tested by the Agency. The Agency has data showing that lead may also be present in K062 wastes generated from pickling operations involving leaded steels. No organics were analyzed for in the untreated and treated K062 waste; however, the Agency does not believe that they will be present in treatable concentrations in the untreated K062 wastes.

Table 2-7 Major Constituent Analysis
Untreated K062 Waste

Constituent	Concentration %
BDAT List Constituents (primarily chromium, copper, and nickel)	1
Water	93
Other Inorganics	6
Total	100

Reference: USEPA 1986.

Table 2-8 BDAT List Constituent Composition

BDAT metals	Untreated waste concentration, ppm	
	(a)	(b)
Arsenic	<0.1 to 3	-
Barium	<10	-
Cadmium	<5	-
Chromium (hexavalent)	0.079 to 1	0.005 to 19
Chromium (total)	6 to 7000	2 to 12,400
Copper	5 to 865	-
Lead	<10	0.12 to 1550
Nickel	4 to 100,310	-
Zinc	<0.4 to 9	-

Reference: (a) USEPA 1986, Tables 6-1 to 6-12 and (b) USEPA 1985, pp. 299 to 300.

3. APPLICABLE/DEMONSTRATED TREATMENT TECHNOLOGIES

This section describes the applicable treatment technologies for the treatment of K062 waste. The Agency identified the applicable treatment technologies based on the waste composition. The technologies considered to be applicable are those that treat BDAT list metals by reducing their concentration and/or their leachability. Included in this section are discussions of those treatment technologies that have been demonstrated on a commercial basis. The treatment technology tested by the Agency, along with its associated performance data, is presented in the following sections. A schematic diagram of the treatment system for K062 tested by the Agency (chromium reduction and chemical precipitation, followed by dewatering of the precipitate) is shown in Figure 4-1.

3.1 Applicable Treatment Technologies

As shown in Section 2, the tested waste primarily contains BDAT list metals, water, and other inorganic constituents. Some of the BDAT list metals reported in the untreated K062 are arsenic, chromium (hexavalent), chromium (total), copper, lead, nickel, and zinc. Other waste characteristics that may affect treatment selection for K062 are filterable solids and oil and grease content. Filterable solids are 0.01 percent (100 mg/l) or less; oil and grease content is less than 10 mg/l.

The Agency has identified treatment technologies that may be applicable to K062 because they are designed to reduce the concentration of BDAT list metals present in the treated residual and/or reduce the leachability of BDAT list metals in the treated residual. The selection of the treatment technologies applicable for treating BDAT list metals in K062 is based on current literature sources and field testing. K062 wastes tested by EPA contain dissolved BDAT list metals (approximately 1 percent), low oil and grease content (<0.2 to 6 mg/l), and low filterable solids (<1 to 100 mg/l). Hence, chemical precipitation followed by dewatering of the precipitated solids is an applicable technology for the removal of the dissolved metals from K062. Applicable treatment for the solids precipitated includes stabilization or metals recovery. Additionally, the presence of hexavalent chromium indicates the need for chromium reduction to convert hexavalent chromium to trivalent chromium prior to precipitation. Dewatering of the precipitated solids results in a nonwastewater stream called filter cake and a wastewater stream called filtrate. The filtrate may be further processed by polishing filtration, such as multimedia filtration, to remove the remaining suspended solids. Stabilization of the filter cake may be used to reduce the leachability of the BDAT list metals. Metals recovery from the filter cake may be used to reduce the total concentration of the metals in the filter cake.

3.2 Demonstrated Treatment Technologies

All of the applicable technologies are demonstrated. Hexavalent chromium reduction, chemical precipitation, and dewatering by settling and/or filtration are widely practiced as a metals treatment technology. In addition, polishing filtration is a well-documented technology. The use of dewatering by vacuum filtration only, as a substitute for settling, is a less commonly practiced technology, but was used on a full-scale basis at a facility tested by EPA. Regarding treatment of precipitated solids, stabilization is well demonstrated on K062 wastes. EPA also has information showing that high temperature metals recovery is a demonstrated technology for K062 wastes. Of the demonstrated treatment technologies, chromium reduction, chemical precipitation, sludge filtration, stabilization, and high temperature metals recovery are discussed below.

3.2.1 Chromium Reduction

(1) Applicability and use of chromium reduction. The process of hexavalent chromium (Cr^{6+}) reduction involves converting chromium from the hexavalent form to the trivalent form. This technology has wide application to hexavalent chromium wastes, including plating solutions, stainless steel acid baths and rinses, "chrome conversion" coating process rinses, and chromium pigment manufacturing wastes. Because this technology requires the pH to be in the acidic range, it would not be applicable to a waste that contains significant amounts of cyanide or sulfide. In such cases, lowering of the pH can generate toxic gases such as hydrogen cyanide or hydrogen sulfide. It is important to note that additional treatment is required to remove trivalent chromium from solution.

(2) Underlying principles of operation. The basic principle of treatment is to reduce the valence of chromium in solution (in the form

of chromate or dichromate ions) from the valence state of six (+6) to the trivalent (+3) state. "Reducing agents" used to effect the reduction include sodium bisulfite, sodium metabisulfite, sulfur dioxide, sodium hydrosulfide, or the ferrous form of iron.

A typical reduction equation, using sodium sulfite as the reducing agent, is:

$$H_2Cr_2O_7 + 3Na_2SO_3 + (SO_4)_3 \rightarrow Cr_2(SO_4)_3 + 3Na_2SO_4 + 4H_2O.$$

The reaction is usually accomplished at pH values in the range of 2 to 3.

At the completion of the chromium reduction step, the trivalent chromium compounds are precipitated from solution by raising the pH to a value exceeding about 8. The less soluble trivalent chromium (in the form of chromium hydroxide) is then allowed to settle from solution. The precipitation reaction is as follows:

$$Cr_2(SO_4)_3 + 3Ca(OH)_2 \rightarrow 2Cr(OH)_3 + CaSO_4.$$

(3) Description of the chromium reduction process. The chromium reduction treatment process can be operated in a batch or a continuous mode. A batch system will consist of a reaction tank, a mixer to homogenize the contents of the tank, a supply of reducing agent, and a source of acid and base for pH control.

A continuous chromium reduction treatment system, as shown in Figure 3-1, will usually include a holding tank upstream of the reaction tank for flow and concentration equalization. It will also include instrumentation to automatically control the amount of reducing agent added and the pH of the reaction tank. The amount of reducing agent is

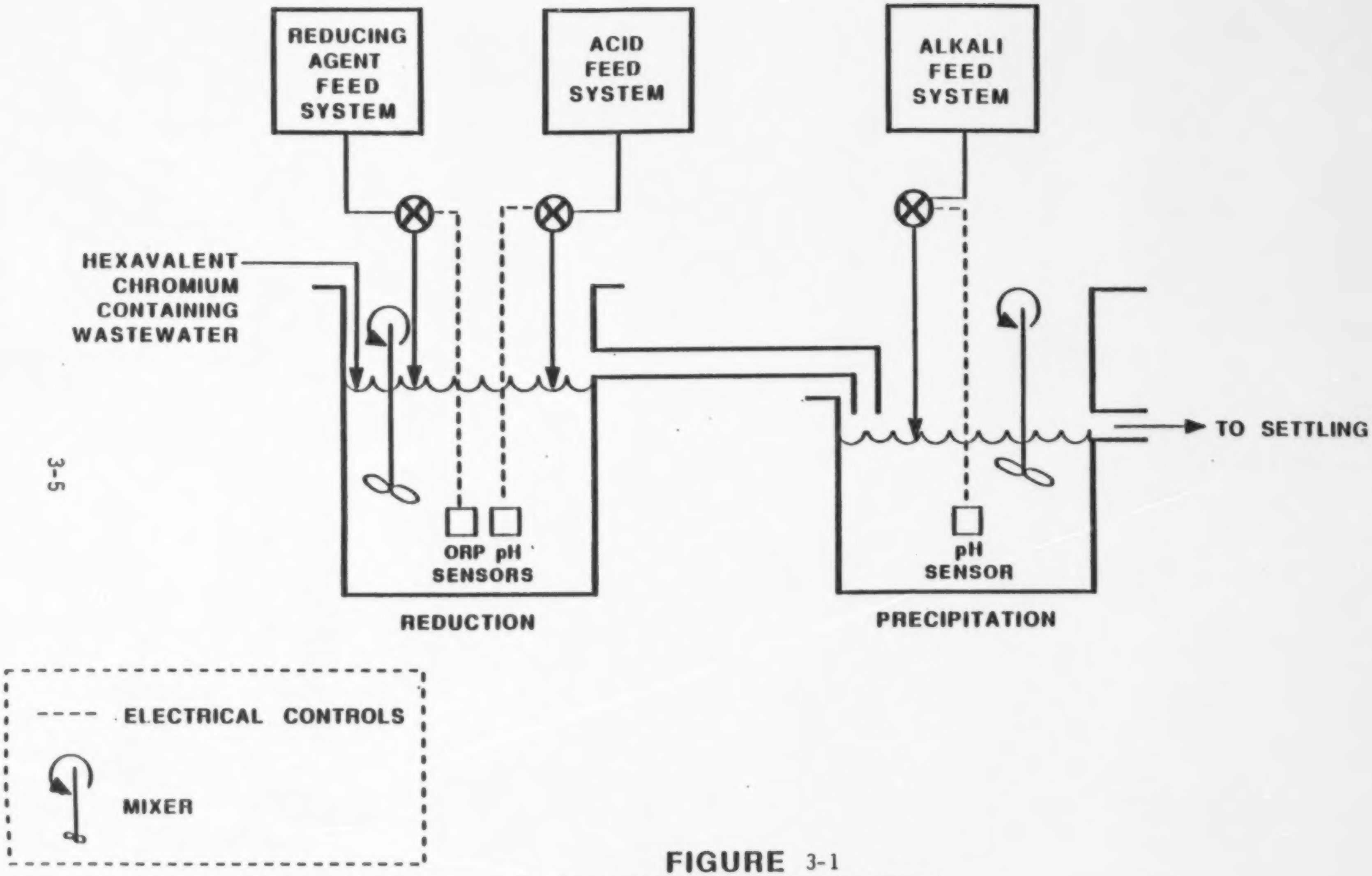

REDUCING AGENT FEED SYSTEM
ACID FEED SYSTEM
ALKALI FEED SYSTEM
HEXAVALENT CHROMIUM CONTAINING WASTEWATER
ORP pH SENSORS
REDUCTION
pH SENSOR
PRECIPITATION
TO SETTLING
ELECTRICAL CONTROLS
MIXER

FIGURE 3-1
CONTINUOUS HEXAVALENT
CHROMIUM REDUCTION SYSTEM

controlled by the use of a sensor called an oxidation reduction potential (ORP) cell. The ORP sensor electronically measures, in millivolts, the level to which the redox reaction has proceeded at any given time. It must be noted, though, that the ORP reading is very pH dependent. Consequently, if the pH is not maintained at a steady value, the ORP will vary somewhat, regardless of the level of chromate reduction.

(4) Waste characteristics affecting performance. In determining whether chromium reduction can treat an untested waste to the same level of performance as a previously tested waste, EPA will examine waste characteristics that affect the reaction involved with either lowering the pH or reducing the hexavalent chromium. EPA believes that such characteristics include the oil and grease content of the waste, total dissolved solids, and the presence of other compounds that would undergo reduction reaction.

(a) Oil and grease. EPA believes that these compounds could potentially interfere with the oxidation-reduction reactions, as well as cause monitoring problems by fouling the instrumentation (e.g., electrodes). Oil and grease concentrations can be measured by EPA Methods 9070 and 9071.

(b) Total dissolved solids. These compounds can interfere with the addition of treatment chemicals into solution and possibly cause monitoring problems.

(c) Other reducible compounds. These compounds would generally consist of other metals in the waste. Accordingly, EPA will evaluate the type and concentration of other metals in the waste when evaluating the transfer of treatment performances.

(5) Design and operating parameters. The parameters that EPA will examine in assessing the design and operation of a chromium reduction treatment system are discussed below.

(a) Treated and untreated design concentration. EPA will need to know the level of performance that the facility is designed to achieve in order to ensure that the design is consistent with best demonstrated practices. This parameter is important since a system will not usually perform better than its design. In addition to awareness of the treated design concentration, it is also important to know the characteristics of the untreated waste that the system is designed to handle. Accordingly, EPA will obtain data on the untreated wastes to ensure that the waste characteristics fall within the design specifications.

(b) Reducing agent. The choice of a reducing agent establishes the chemical reaction upon which the chromium reduction system is based. The amount of reducing agent must be monitored and controlled in both batch and continuous systems. In batch systems, the reducing agent is usually controlled by an analysis of the hexavalent chromium remaining in the solution. For continuous systems, the ORP reading is used to monitor and control the addition of a reducing agent.

The ORP reading will change slowly until the correct amount of reducing agent has been added, at which point the reading will change more rapidly, indicating that the reaction has been completed. The setpoint for the ORP monitor is approximately the reading just after the rapid change has begun. The reduction system must then be monitored periodically to determine whether the selected setpoint needs further adjustment.

(c) pH. For both batch and continuous systems, pH is an important parameter because of its effect on the reduction reaction. While it can be monitored intermittently during treatment for a batch system, the pH should be monitored continuously for continuous systems because of its effect on the ORP. In evaluating the design and operation of a continuous chromium reduction system, it is important to know the pH on which the design ORP value is based, as well as the designed ORP value.

(d) Retention time. Retention time should be adequate to ensure that the hexavalent chromium reduction reaction goes to completion. In the case of the batch reactor, the retention time is varied by adjusting the treatment time in the reaction tank. If the process is continuous, it is important to monitor the feed rate to ensure that the designed residence time is achieved.

The chromium reduction process that provides data for treating K062 used iron-bearing (ferrous) acid wastes to reduce hexavalent chromium to trivalent chromium in a single stage batch reaction. Each treatment tank used a mechanical mixing system. According to plant personnel, the weight ratio of ferrous iron to hexavalent chromium required for complete reduction is 3.2 to 1.0. Some industrial treatment facilities, however, often use other amounts of iron to ensure complete reduction of the hexavalent chromium. Completion of the chromium reduction step was checked by measuring the hexavalent chromium concentration until it was no longer detected in the treatment tank.

3.2.2 Chemical Precipitation

(1) Applicability and use of chemical precipitation. Chemical precipitation is used when dissolved metals are to be removed from solution. This technology can be applied to a wide range of wastewaters containing dissolved BDAT list metals and other metals as well. This treatment process has been practiced widely by industrial facilities since the 1940s.

(2) Underlying principles of operation. The underlying principle of chemical precipitation is that metals in wastewater are removed by the addition of a treatment chemical that converts the dissolved metal to a metal precipitate. This precipitate is less soluble than the original metal compound and therefore settles out of the solution, leaving a lower concentration of the metal present in the solution. The primary chemicals used to convert soluble metal compounds to less soluble forms include: lime ($Ca(OH)_2$), caustic (NaOH), sodium sulfide (Na_2S), and, to a lesser extent, soda ash (Na_2CO_3), phosphate, and ferrous sulfide (FeS).

The solubility of a particular compound will depend on the extent to which the electrostatic forces holding the ions of the compound together can be overcome. The solubility will change significantly with temperature; most metal compounds are more soluble as the temperature increases. Additionally, the solubility will be affected by the other constituents present in a waste. As a general rule, nitrates, chlorides, and sulfates are more soluble than hydroxides, sulfides, carbonates, and phosphates.

An important concept related to treatment of the soluble metal compounds is pH. This term provides a measure of the extent to which a solution contains either an excess of hydrogen or hydroxide ions. The pH scale ranges from 0 to 14, with 0 being the most acidic, 14 representing the highest alkalinity or hydroxide ion (OH^-) content, and 7.0 being neutral.

When hydroxide is used, as is often the case, to precipitate the soluble metal compounds, the pH is frequently monitored to ensure that sufficient treatment chemicals are added. It is important to point out that pH is not a good measure of treatment chemical addition for compounds other than hydroxides. When sulfide is used, for example, facilities might use an oxidation-reduction potential meter (ORP) correlation to ensure that sufficient treatment chemical is used.

Following conversion of the relatively soluble metal compounds to metal precipitates, the effectiveness of chemical precipitation is a function of the physical removal, which usually relies on a settling process. A particle of a specific size, shape, and composition will settle at a specific velocity, as described by Stokes' Law. For a batch system, Stokes' Law is a good predictor of settling time because the pertinent particle parameters remain essentially constant. Nevertheless, in practice, settling time for a batch system is normally determined by empirical testing. For a continuous system, the theory of settling is complicated by factors such as turbulence, short-circuiting, and velocity gradients, increasing the importance of the empirical tests.

(3) Description of the chemical precipitation process. The equipment and instrumentation required for chemical precipitation vary depending on whether the system is batch or continuous. Both operations are discussed below; a schematic of the continuous system is shown in Figure 3-2.

For a batch system, chemical precipitation requires only a feed system for the treatment chemicals and a second tank where the waste can be treated and allowed to settle. When lime is used, it is generally added to the reaction tank in a slurry form. In a batch system, the supernate is usually analyzed before discharge, thus minimizing the need for instrumentation.

In a continuous system, additional tanks and instrumentation are necessary to ensure that the system is operating properly. In this system, the first tank that the wastewater enters is referred to as an equalization tank. This is where the waste can be mixed in order to provide more uniformity, minimizing wide swings in the type and concentration of constituents being sent to the reaction tank. It is important to reduce the variability of the waste sent to the reaction tank because control systems inherently are limited with regard to the maximum fluctuations that can be managed.

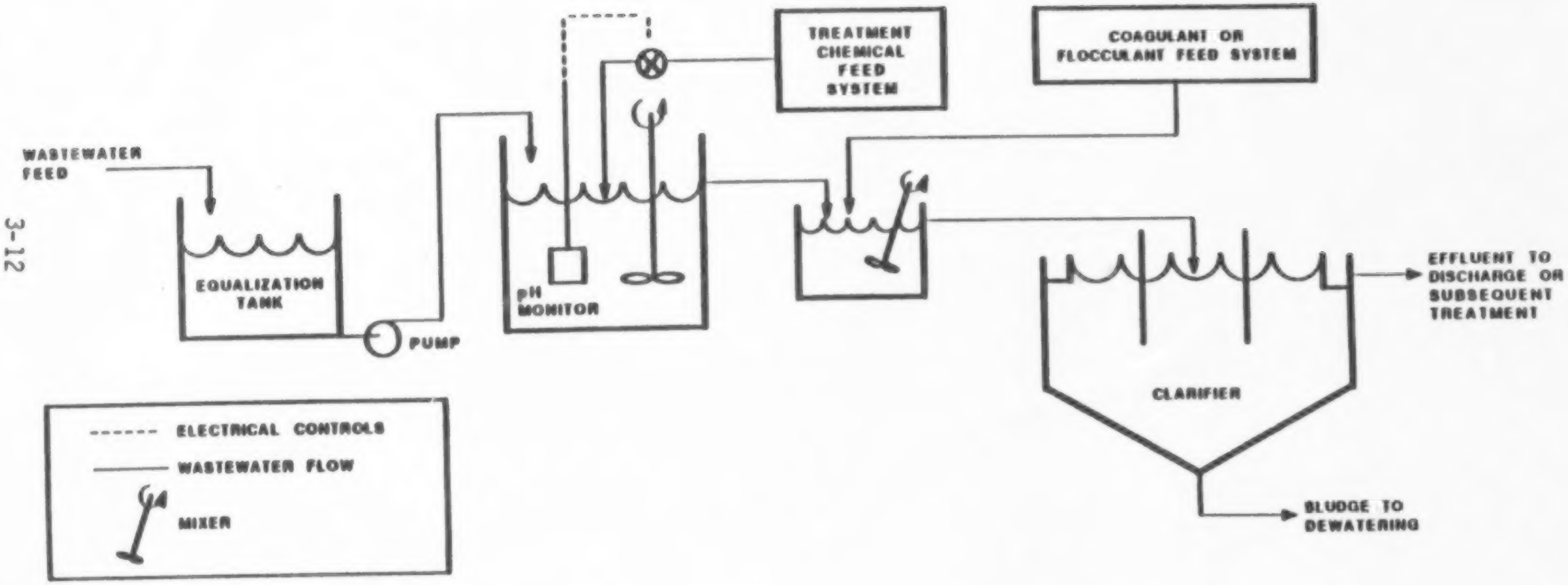

WASTEWATER FEED
EQUALIZATION TANK
PUMP
pH MONITOR
TREATMENT CHEMICAL FEED SYSTEM
COAGULANT OR FLOCCULANT FEED SYSTEM
CLARIFIER
EFFLUENT TO DISCHARGE OR SUBSEQUENT TREATMENT
SLUDGE TO DEWATERING
ELECTRICAL CONTROLS
WASTEWATER FLOW
MIXER

FIGURE 3-2 CONTINUOUS CHEMICAL PRECIPITATION

Following equalization, the waste is pumped to a reaction tank where treatment chemicals are added; this is done automatically by using instrumentation that senses the pH of the system and then pneumatically adjusts the position of the treatment chemical feed valve so that the design pH value is achieved. Both the complexity and the effectiveness of the automatic control system will vary depending on variations in the waste and the pH range needed to properly treat the waste.

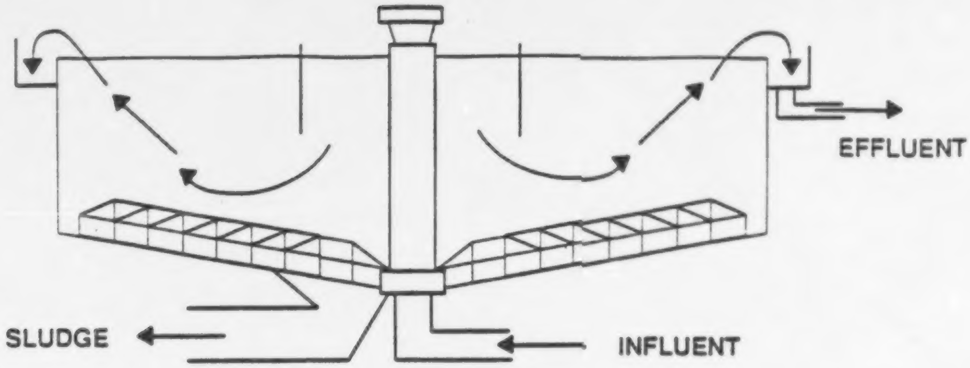
It is important that the reaction tank be designed to assure that the waste is well mixed and that the waste and the treatment chemicals are both dispersed throughout the tank. This ensures commingling of the reactant and the treatment chemicals. In addition, effective dispersion of the treatment chemicals throughout the tank is necessary to properly monitor and thereby control the amount of treatment chemicals added.

After the waste is reacted with the treatment chemical, it flows to a quiescent tank where the precipitate is allowed to settle and subsequently be removed. Settling can be chemically assisted through the use of flocculating compounds. Flocculants increase the particle size and the density of the precipitated solids, both of which increase the rate of settling. The particular flocculating agent that will best improve the settling characteristics will vary depending on the particular waste; selection of the flocculating agent is generally accomplished by performing laboratory bench tests. Settling can be conducted in a large tank by relying solely on gravity or can be mechanically assisted through the use of a circular clarifier or an inclined separator. Schematics of the two separators are shown in Figures 3-3 and 3-4.

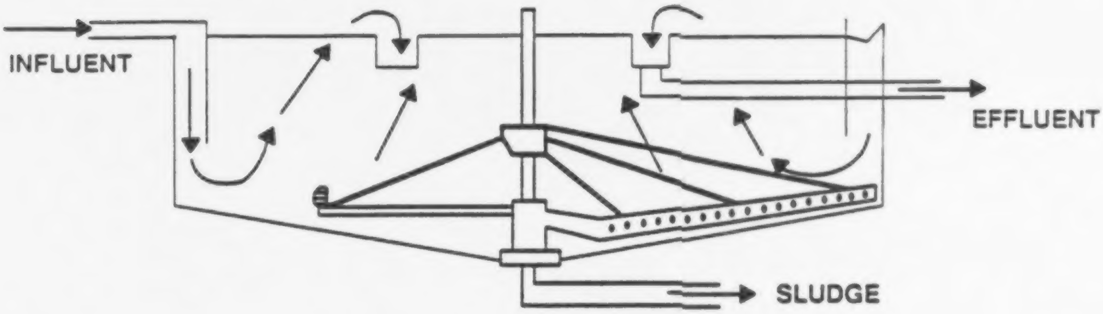
Filtration can be used for further removal of precipitated residuals both in cases where the settling system is underdesigned and in those in which the particles are difficult to settle. Polishing filtration is discussed in a separate technology section.

(4) Waste characteristics affecting performance. In determining whether chemical precipitation is likely to achieve the same level of performance on an untested waste as on a previously tested waste, the following waste characteristics will be examined: (a) the concentration and type of the metal(s) in the waste, (b) the concentration of suspended solids (TSS), (c) the concentration of dissolved solids (TDS), (d) whether the metal exists in the wastewater as a complex, and (e) the oil and grease content. These parameters affect the chemical reaction of the metal compound, the solubility of the metal precipitate, or the ability of the precipitated compound to settle.

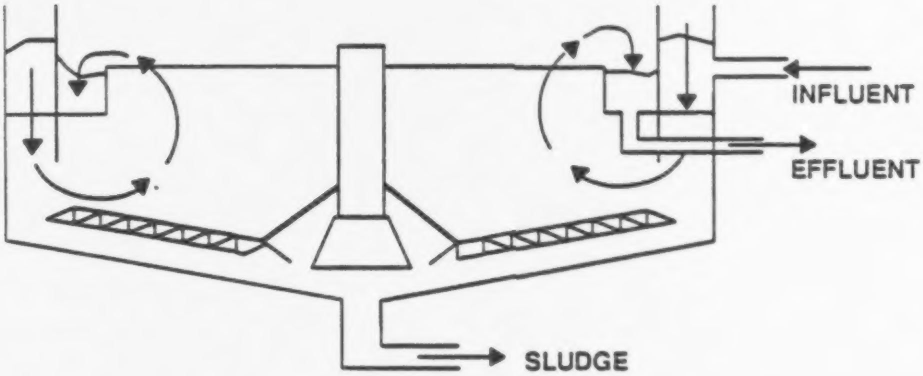
(a) Concentration and type of metals. For most metals, there is a specific pH at which the metal hydroxide is least soluble. As a result, when a waste contains a mixture of many metals, it is not possible to operate a treatment system at a single pH that is optimal for the removal of all metals. The extent to which this affects treatment depends on the particular metals to be removed and their concentrations. An alternative can be to operate multiple precipitations, with intermediate settling, when the optimum pH occurs at markedly different


EFFLUENT
SLUDGE
INFLUENT

CENTER FEED CLARIFIER WITH SCRAPER SLUDGE REMOVAL SYSTEM


INFLUENT
EFFLUENT
SLUDGE

RIM FEED - CENTER TAKEOFF CLARIFIER WITH HYDRAULIC SUCTION SLUDGE REMOVAL SYSTEM


INFLUENT
EFFLUENT
SLUDGE

RIM FEED - RIM TAKEOFF CLARIFIER

FIGURE 3-3 CIRCULAR CLARIFIERS

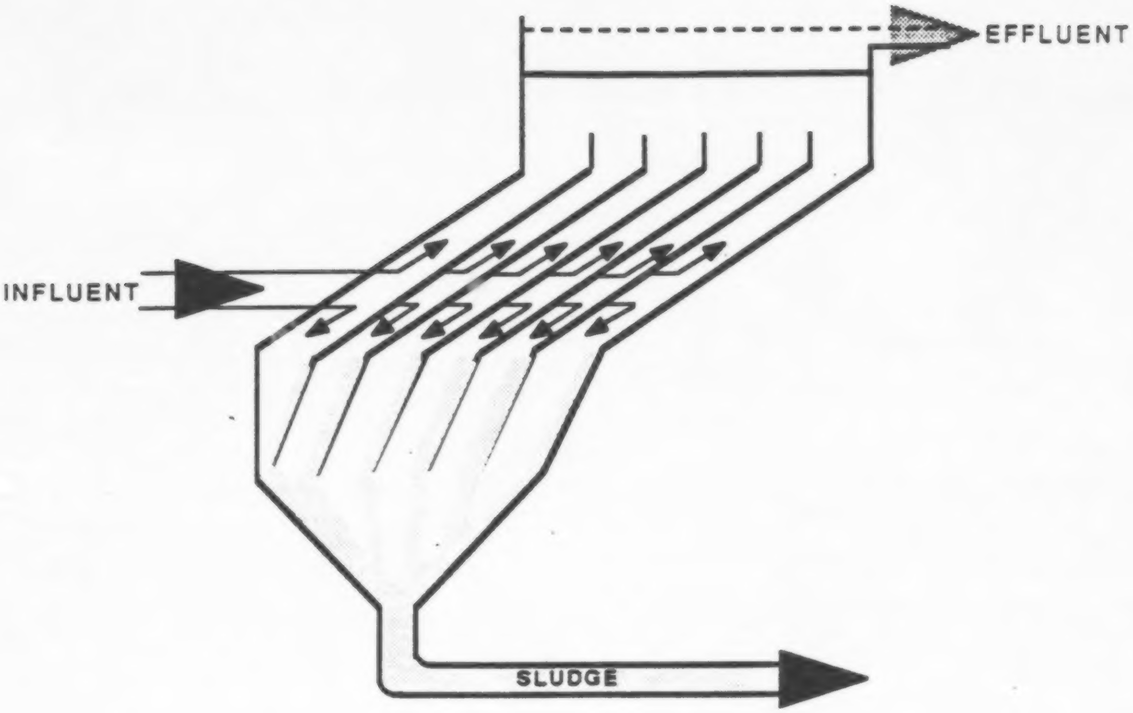

EFFLUENT
INFLUENT
SLUDGE

FIGURE 3-4
INCLINED PLATE SETTLER

levels for the metals present. The individual metals and their concentrations can be measured using EPA Method 6010.

(b) Concentration and type of total suspended solids (TSS). Certain suspended solid compounds are difficult to settle because of their particle size or shape. Accordingly, EPA will evaluate this characteristic in assessing transfer of treatment performance. Total suspended solids can be measured by EPA Wastewater Test Method 160.2.

(c) Concentration of total dissolved solids (TDS). Available information shows that total dissolved solids can inhibit settling. The literature states that poor flocculation is a consequence of high TDS, and shows that higher concentrations of total suspended solids are found in treated residuals. Poor flocculation can adversely affect the degree to which precipitated particles are removed. Total dissolved solids can be measured by EPA Wastewater Test Method 160.1.

(d) Complexed metals. Metal complexes consist of a metal ion surrounded by a group of other inorganic or organic ions or molecules (often called ligands). In the complexed form, metals have a greater solubility and therefore may not be as effectively removed from solution by chemical precipitation. EPA does not have an analytical method to determine the amount of complexed metals in the waste. The Agency believes that the best measure of complexed metals is to analyze for some common complexing compounds (or complexing agents) generally found in wastewater for which analytical methods are available. These complexing agents include ammonia, cyanide, and EDTA. The analytical method for cyanide is EPA Method 9010. The method for EDTA is ASTM Method D3113. Ammonia can be analyzed using EPA Wastewater Test Method 350.

(e) Oil and grease content. The oil and grease content of a particular waste directly inhibits the settling of the precipitate. Suspended oil droplets float in water and tend to suspend particles such as chemical precipitates that would otherwise settle out of the solution. Even with the use of coagulants or flocculants, the separation of the precipitate is less effective. Oil and grease content can be measured by EPA Method 9071.

(5) Design and operating parameters. The parameters that EPA will evaluate when determining whether a chemical precipitation system is well designed are: (a) design value for treated metal concentrations, as well as other characteristics of the waste used for design purposes (e.g., total suspended solids), (b) pH, (c) residence time, (d) choice of treatment chemical, (e) choice of coagulant/flocculant, and (f) degree of mixing. Below is an explanation of why EPA believes these parameters are important to a design analysis, as well as an explanation of why other design criteria are not included in EPA's analysis.

(a) Treated and untreated design concentrations. EPA pays close attention to the treated concentration the system is designed to achieve when determining whether to sample a particular facility. Since the system will seldom outperform its design, EPA must evaluate whether the design is consistent with best demonstrated practice.

The untreated concentrations that the system is designed to treat are important in evaluating any treatment system. Operation of a chemical precipitation treatment system with untreated waste concentrations in excess of design values can easily result in poor performance.

(b) pH. The pH is important because it can indicate that sufficient treatment chemical (e.g., lime) is added to convert the metal constituents in the untreated waste to forms that will precipitate. The pH also affects the solubility of metal hydroxides and sulfides, and therefore directly impacts the effectiveness of removal. In practice, the design pH is determined by empirical bench testing, often referred to as "jar" testing. The temperature at which the "jar" testing is conducted is important in that it also affects the solubility of the metal precipitates. Operation of a treatment system at temperatures above the design temperature can result in poor performance. In assessing the operation of a chemical precipitation system, EPA prefers continuous data on the pH and periodic temperature conditions throughout the treatment period.

(c) Residence time. Residence time is important because it impacts the completeness of the chemical reaction to form the metal precipitate and, to a greater extent, the amount of precipitate that settles out of the solution. In practice, it is determined by "jar" testing. For continuous systems, EPA will monitor the feed rate to ensure that the system is operated at design conditions. For batch systems, EPA will want information on the design parameter used to determine sufficient settling time (e.g., total suspended solids).

(d) Choice of treatment chemical. A choice must be made as to what type of precipitating agent (i.e., treatment chemical) will be used. The factor that most affects this choice is the type of metal constituents to be treated. Other design parameters, such as pH, residence time, and choice of coagulant/flocculant agents, are based on the selection of the treatment chemical.

(e) Choice of coagulant/flocculant. This parameter is important because these compounds improve the settling rate of the precipitated metals and allow smaller systems (i.e., lower retention time) to achieve the same degree of settling as much larger systems. In practice, the choice of the best agent and the required amount is determined by "jar" testing.

(f) Degree of mixing. The degree of mixing is a complex assessment that includes, among other things, the energy supplied, the time the material is mixed, and the related turbulence effects of the specific size and shape of the tank. EPA will, however, consider whether mixing is provided and whether the type of mixing device is one that could be expected to achieve uniform mixing. For example, EPA may not use data from a chemical precipitation treatment system in which an air hose was placed in a large tank to achieve mixing.

3.2.3 Sludge Filtration

(1) Applicability and use of sludge filtration. Sludge filtration, also known as sludge dewatering or cake-formation filtration, is a technology used on wastes that contain high concentrations of suspended

solids, generally higher than 1 percent. The remainder of the waste is essentially water. Sludge filtration is applied to sludges, typically those that have settled to the bottom of clarifiers, for dewatering. After filtration, these sludges can be dewatered to 20 to 50 percent solids.

(2) Underlying principle of operation. The basic principle of filtration is the separation of particles from a mixture of fluids and particles by a medium that permits the flow of the fluid but retains the particles. As would be expected, larger particles are easier to separate from the fluid than smaller particles. Extremely small particles, in the colloidal range, may not be filtered effectively and may appear in the treated waste. To mitigate this problem, the wastewater should be treated prior to filtration to modify the particle size distribution in favor of the larger particles, by the use of appropriate precipitants, coagulants, flocculants, and filter aids. The selection of the appropriate precipitant or coagulant is important because it affects the particles formed. For example, lime neutralization usually produces larger, less gelatinous particles than does caustic soda precipitation. For larger particles that become too small to filter effectively because of poor resistance to shearing, shear resistance can be improved by the use of coagulants and flocculants. Also, if pumps are used to feed the filter, shear can be minimized by designing for a lower pump speed, or by use of a low shear type of pump.

(3) Description of the sludge filtration Process. For sludge filtration, settled sludge is either pumped through a cloth-type filter media (such as in a plate and frame filter that allows solid "cake" to build up on the media) or the sludge is drawn by vacuum through the cloth media (such as on a drum or vacuum filter, which also allows the solids to build). In both cases the solids themselves act as a filter for subsequent solids removal. For a plate and frame type filter, removal of the solids is accomplished by taking the unit off line, opening the filter, and scraping the solids off. For the vacuum type filter, cake is removed continuously. For a specific sludge, the plate and frame type filter will usually produce a drier cake than a vacuum filter. Other types of sludge filters, such as belt filters, are also used for effective sludge dewatering.

(4) Waste characteristics affecting performance. The following characteristics of the waste will affect the performance of a sludge filtration unit: (a) size of particles and (b) type of particles.

(a) Size of particles. The smaller the particle size, the more the particles tend to go through the filter media. This is especially true for a vacuum filter. For a pressure filter (like a plate and frame), smaller particles may require higher pressures for equivalent throughput, since the smaller pore spaces between particles create resistance to flow.

(b) Type of particles. Some solids formed during metal precipitation are gelatinous in nature and cannot be dewatered well by cake-formation filtration. In fact, for vacuum filtration a cake may not form at all. In most cases, solids can be made less gelatinous by use of the appropriate coagulants and coagulant dosage prior to clarification, or after clarification but prior to filtration. In addition, the use of lime instead of caustic soda in metal precipitation will reduce the formation of gelatinous solids. Also, the addition of filter aids to a gelatinous sludge, such as lime or diatomaceous earth, will help significantly. Finally, precoating the filter with diatomaceous earth prior to sludge filtration will assist in dewatering gelatinous sludges.

(5) Design and operating parameters. For sludge filtration, the following design and operating variables affect performance: (a) type of filter selected, (b) size of filter selected, (c) feed pressure, and (d) use of coagulants or filter aids.

(a) Type of filter. Typically, pressure type filters (such as a plate and frame) will yield a drier cake than a vacuum type filter and will also be more tolerant of variations in influent sludge characteristics. Pressure type filters, however, are batch operations, so that when cake is built up to the maximum depth physically possible (constrained by filter geometry), or to the maximum design pressure, the filter is turned off while the cake is removed. A vacuum filter is a continuous device (i.e., cake discharges continuously), but will usually be much larger than a pressure filter with the same capacity. A hybrid device is a belt filter, which mechanically squeezes sludge between two continuous fabric belts.

(b) Size of filter. As with in-depth filters, the larger the filter, the greater its hydraulic capacity and the longer the filter runs between cake discharge.

(c) Feed pressure. This parameter impacts both the design pore size of the filter and the design flow rate. It is important that when treating waste the design feed pressure not be exceeded; otherwise, particles may be forced through the filter medium, resulting in ineffective treatment.

(d) Use of coagulants. Coagulants and filter aids may be mixed with filter feed prior to filtration. Their effect is particularly significant for vacuum filtration since they may make the difference between no cake and a relatively dry cake in a vacuum filter. In a pressure filter, coagulants and filter aids will also significantly improve hydraulic capacity and cake dryness. Filter aids, such as diatomaceous earth, can be precoated on filters (vacuum or pressure) for particularly difficult to filter sludges. The precoat layer acts somewhat like an in-depth filter in that sludge solids are trapped in the precoat pore spaces. Use of precoats and most coagulants or filter aids significantly increases the amount of sludge solids to be disposed of. However, polyelectrolyte coagulant usage usually does not increase sludge volume substantially because the dosage is low.

Two rotary drum vacuum filters were used for the separation of solids after the precipitation step. These filters operated between 18 and 26 inches Hg vacuum, with filter cake being discharged continuously. The filter cake contained about 20 to 40 weight percent total dry solids. The filtration rate was about 40 gpm. The vacuum filters were precoated with diatomaceous earth and rotated at 1.07 to 1.3 rpm.

3.2.4 High Temperature Metals Recovery

High temperature metals recovery (HTMR) provides for recovery of metals from wastes primarily by volatilization of the metals to be recovered, subsequent condensation from the gas phase, and product collection steps. The process yields metal products for reuse and substantially reduces the concentration of metals in the residual. This process also significantly reduces the amount of treated waste that needs to be land disposed.

There are a number of different types of high temperature metals recovery systems. These systems generally differ from one another relative to the source of energy and the method of recovery. Such HTMR systems include the rotary kiln process, the plasma arc reactor, the rotary hearth/electric furnace system, the molten slag reactor, and the flame reactor. This technology differs from retorting in that HTMR is conducted in a carbon reducing atmosphere, while the retorting process simply vaporizes the untreated metal.

(1) Applicability and use of high temperature metals recovery. This process is applicable to wastes containing BDAT list metals and having a low water content (or a water content that can be either blended to the required level or lowered by dewatering) and a low concentration of

organics. This technology is applicable to a wide range of metal salts including cadmium, chromium, lead, mercury, nickel, and zinc.

This process is generally not used for mercury-containing wastes even though mercury will volatilize readily at the process temperatures present in high temperature units. The rotary kiln recovery process is one example of the technology, and has been applied to zinc-bearing wastes as an upgrading step that yields a zinc oxide product for further refinement and subsequent reuse. Although this technology was originally developed in the 1920s for upgrading zinc from ores, it has recently been applied to electric furnace dust from the steel-making industry.

(2) Underlying principles of operation. The underlying principle of operation for this technology is that metals are separated from a waste through volatilization in a reducing atmosphere where carbon is the reducing compound. An example chemical reaction would be:

$$2ZnO + C \rightarrow 2Zn + CO_2.$$

In some cases, the waste contains not only BDAT list metal constituents that can be volatilized but also nonvolatile BDAT list metals as well. In such cases, the HTMR process can yield two recoverable product streams. Whether such recovery can be accomplished, however, depends on the type and concentration of metals in the original wastestream. Below is a discussion of the recovery techniques for the volatile stream, as well as the waste material that is not volatilized.

(a) Recovery of volatilized metals. The volatilized metals can be recovered in the metallic form or as an oxide. Recovery is accomplished in the case of the metallic form by condensation alone, and, in the case of the oxide, by reoxidation, condensation, and subsequent collection of the metal oxide particulates in a baghouse. There is no difference between these two types of metal product recovery systems relative to the kinds of waste that can be treated; the difference is simply reflected in a facility's preference relative to product purity. In the former case, the direct condensation of metals, while more costly, allows for the separation and collection of metals in a relatively uncontaminated form; in the latter case, the metals are collected as a combination of several metal oxides. If necessary, this combination of metal oxides could be further processed to produce individual metal products of increased purity.

(b) Less volatile treatment residual. The fraction of the waste that is not originally volatilized has three possible dispositions: (1) the material is such that it can be used directly as a product (e.g., a waste residual containing mostly metallic iron can be reused directly in steel making); (2) the material can be reused after further processing (e.g., a waste residual containing oxides of iron, chromium, and nickel can be reduced to the metallic form and then recovered for use in the manufacture of stainless steel); and (3) the material has no recoverable value and is land disposed as a slag.

(3) Description of the high temperature metals recovery process. The process essentially consists of four operations: (1) a blending operation to control feed parameters, (2) high temperature processing,

(3) a product collection system, and (4) handling of the less volatile treated residual. A generic schematic diagram for high temperature metals recovery is shown in Figure 3-5.

(a) Blending operation. For the system shown, variations in feeds are minimized by blending wastes from different sources. Prior to feeding the kiln, fluxing agents are added to the waste. Carbon is also added to the waste as required. The fluxes (limestone or sand) are added to react with certain waste components to prevent their volatilization, thus improving the purity of the desired metals recovered. In addition, the moisture content is adjusted by either adding water or blending various wastes.

(b) High temperature processing. These materials are fed to the furnace where they are heated and the chemical reactions take place. The combination of residence time and turbulence helps to ensure the maximum volatilization of the metal constituents.

(c) Product collection system. The product collection system can consist of either a condenser or a combination condenser and baghouse. As noted previously, the particular system depends on whether the metal is to be collected in the metallic form or as an oxide.

(d) Handling the less volatile treated residual. The equipment needed to handle the less volatile metal-treated residual depends on the final disposition of the material. If further recovery is performed, then the waste would be treated in another furnace. If the material were to be land disposed, the final process step would generally consist of quenching.

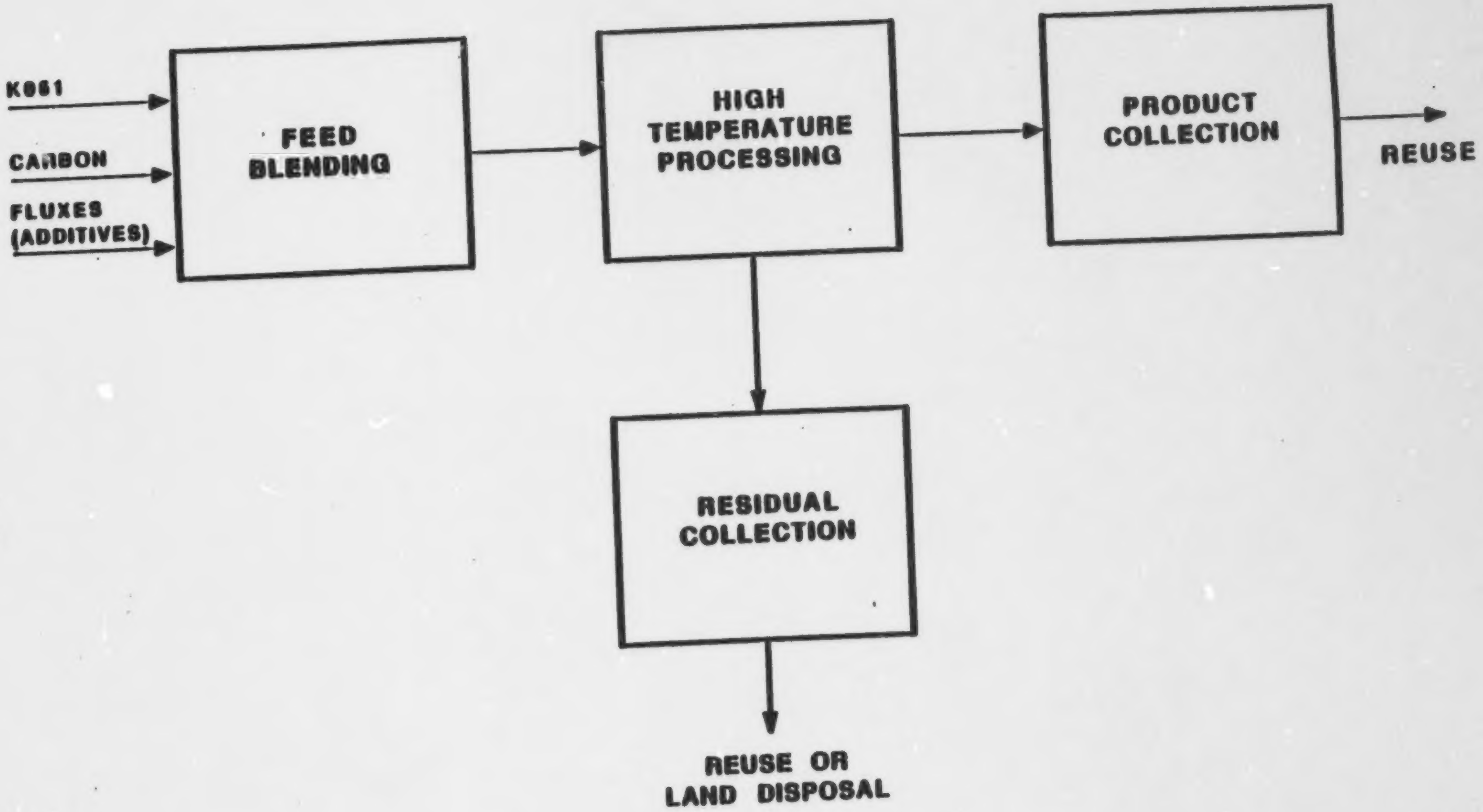

K061
CARBON
FLUXES (ADDITIVES)
FEED BLENDING
HIGH TEMPERATURE PROCESSING
PRODUCT COLLECTION
REUSE
RESIDUAL COLLECTION
REUSE OR LAND DISPOSAL

FIGURE 3-5 EXAMPLE HIGH TEMPERATURE METALS RECOVERY SYSTEM

(4) Waste characteristics affecting performance. In determining whether high temperature metals recovery technologies are likely to achieve the same level of performance on an untested waste as on a previously tested waste, EPA will examine the following three waste characteristics that have an impact on treatability: (1) type and concentrations of metals in the waste, (2) relative volatility of the metals, and (3) heat transfer characteristics of the waste.

(a) Type and concentrations of metals in the waste. Because this is a metals recovery process, the product must meet certain requirements for recovery. If the waste contains other volatile metals that are difficult to separate and whose presence may affect the ability to refine the product for subsequent reuse, high temperature metals recovery may provide less effective treatment. Analytical methods for metals can be found in SW-846.

(b) Boiling point. The relative volatilities of the metals in the waste also affect the ability to separate various metals. There is no conventional measurement technique for determining the relative volatility of a particular constituent in a given waste. EPA believes that the best measure of volatility of a specific metal constituent is the boiling point. EPA recognizes that the boiling point has certain shortcomings, primarily the fact that boiling points are given for pure components, while it is clear that other constituents in the waste will also affect partial pressures and thus the boiling point of the mixture. EPA has not identified a parameter that can better assess relative volatility. Boiling points of metals can be determined from the literature.

(c) Heat transfer characteristics. The ability to heat constituents within a waste matrix is a function of the heat transfer characteristics of a heterogeneous waste material. The constituents being recovered from the waste must be heated near or above their boiling points in order for them to be volatilized and recovered. Whether sufficient heat will be transferred to the particular constituent to cause the metal to volatilize will depend on the heat transfer characteristics of the waste. There is no conventional direct measurement of the heat transfer characteristics of a waste. EPA believes that the best measure of these characteristics is thermal conductivity. The analytical method that EPA has identified for measurement of thermal conductivity is named "Guarded, Comparative, Longitudinal Heat Flow Technique"; it is described in Appendix C of this document.

(5) Design and operating parameters. The parameters that EPA will evaluate when determining whether a high temperature metals recovery system is well designed and well operated are (a) the furnace temperature, (b) the furnace residence time, (c) the amount and ratio of the feed blending materials, and (d) mixing. Below is an explanation of why EPA believes these parameters are important to an analysis of the design and operation of the system.

(a) Furnace temperature. In order for sufficient heat to be transferred to the waste for volatilization, high temperatures must be provided. The higher the temperature in the furnace, the more likely it is that the constituents will react with carbon to form free metals and volatilize. The temperature must be approximately equal to or greater than the boiling point of the metals being volatilized. Excessive temperatures could volatilize unwanted metals into the product, possibly inhibiting the potential for reuse of the volatilized product. In assessing performance during the treatment period, EPA would want continuous temperature data.

(b) Furnace residence time. Furnaces must be designed to ensure that the waste has sufficient time to be heated to the boiling point of the metals to be volatilized. The time necessary for complete volatilization of these constituents is dependent upon the furnace temperature and the heat transfer characteristics of the waste. The residence time is a function of the physical dimensions of the furnace (length, diameter, and slope (for rotary kilns)), the rate of rotation (if applicable), and the feed rate.

(c) Amount and ratio of feed blending materials. For the maximum volatilization of the metals being recovered, feed parameters such as carbon content, moisture content, calcium-to-silica ratio, and the initial concentration of the metals to be recovered must be controlled by the addition of carbon, fluxes, and other agents, if necessary. Blending of such components is also needed to adjust the feed to the required volume. The feed parameters all affect the rate of the reduction reaction and volatilization. EPA will examine blending ratios during treatment to ensure that they comply with design conditions.

(d) Mixing. Effective mixing of the total components is necessary to ensure that a uniform waste is being treated. Turbulence in the furnace also ensures that no "pockets" of waste go untreated. Accordingly, EPA will examine the type and degree of mixing involved when assessing treatment design and performance.

3.2.5 Stabilization

Stabilization refers to a broad class of treatment processes that chemically reduce the mobility of hazardous constituents in a waste. Solidification and fixation are other terms that are sometimes used synonymously for stabilization or to describe specific variations within the broader class of stabilization. Related technologies are encapsulation and thermoplastic binding; however, EPA considers these technologies to be distinct from stabilization in that the operational principles are significantly different.

(1) Applicability and use of stabilization. Stabilization is used when a waste contains metals that will leach from the waste when it is contacted by water. In general, this technology is applicable to wastes that contain BDAT list metals and have a high filterable solids content, low TOC content, and low oil and grease content. Stabilization is commonly used to treat residuals generated from treatment of electroplating wastewaters. This technology does not destroy, recover, or otherwise change the waste constituents, but is used to reduce the

leachability of hazardous metal constituents. For some wastes, an alternative to stabilization is metals recovery.

(2) Underlying principles of operation. The basic principle underlying this technology is that stabilizing agents and other chemicals are added to a waste to minimize the amount of metal that leaches. The reduced leachability is accomplished by the formation of a lattice structure and/or chemical bonds that bind the metals to the solid matrix and thereby limit the amount of metal constituents that can be leached when water or a mildly acid solution comes into contact with the waste material.

The two principal stabilization processes used are the cement-based process and the lime/pozzolan-based process. A brief discussion of each is provided below. In both cement-based or lime/pozzolan-based techniques, the stabilizing process can be modified through the use of additives, such as silicates, that control curing rates or enhance the properties of the solid material.

(a) Portland cement-based process. Portland cement is a mixture of powdered oxides of calcium, silica, aluminum, and iron, produced by kiln burning of materials rich in calcium and silica at high temperatures (i.e., 1,400 to 1,500°C). When the anhydrous cement powder is mixed with water, hydration occurs and the cement begins to set. The chemistry involved is complex because many different reactions occur depending on the composition of the cement mixture.

As the cement begins to set, a colloidal gel of indefinite composition and structure is formed. Over a period of time, the gel swells and forms a matrix composed of interlacing, thin, densely packed silicate fibrils. Constituents present in the waste slurry (e.g., hydroxides and carbonates of various heavy metals) are incorporated into the interstices of the cement matrix. The high pH of the cement mixture tends to keep metals in the form of insoluble hydroxide and carbonate salts. It has been hypothesized that metal ions may also be incorporated into the crystal structure of the cement matrix, but this hypothesis has not been verified.

(b) Lime/pozzolan-based process. Pozzolan, which contains finely divided, noncrystalline silica (e.g., fly ash or components of cement kiln dust), is a material that is not cementitious in itself, but becomes so upon the addition of lime. Metals in the waste are converted to silicates or hydroxides that inhibit leaching. Additives, again, can be used to reduce permeability and thereby further decrease leaching potential.

(3) Description of the stabilization process. In most stabilization processes, the waste, stabilizing agent, and other additives, if used, are mixed and then pumped to a curing vessel or area and allowed to cure. The actual operation (equipment requirements and process sequencing) will depend on several factors such as the nature of the waste, the quantity of the waste, the location of the waste in relation to the disposal site, the particular stabilization formulation

to be used, and the curing rate. After curing, the solid formed is recovered from the processing equipment and shipped for final disposal.

In instances where waste contained in a lagoon is to be treated, the material should be first transferred to mixing vessels where stabilizing agents are added. The mixed material is then fed to a curing pad or vessel. After curing, the solid formed is removed for disposal. Equipment commonly used also includes facilities to store the waste and chemical additives. Pumps can be used to transfer liquid or light sludge wastes to the mixing pits and pumpable uncured wastes to the curing site. Stabilized wastes are then removed to a final disposal site.

Commercial concrete mixing and handling equipment generally can be used with wastes. Weighing conveyors, metering cement hoppers, and mixers similar to concrete batching plants have been adapted in some operations. Where extremely dangerous materials are being treated, remote-control and in-drum mixing equipment, such as that used with nuclear waste, can be employed.

(4) Waste characteristics affecting performance. In determining whether stabilization is likely to achieve the same level of performance on an untested waste as on a previously tested waste, the Agency will focus on the characteristics that inhibit the formation of either the chemical bonds or the lattice structure. The characteristics EPA has identified as affecting treatment performance are: (a) other metals and their concentrations, (b) fine particulates, (c) oil and grease, (d) organic compounds, and (e) certain inorganic compounds.

(a) Other metals and their concentrations. When a waste contains a mixture of metals, it may not be possible to chemically stabilize the waste in a manner that optimizes the reduction in leachability for all constituents. The extent to which synergistic effects impact performance will depend on the type and concentration of other metals in the waste. The individual metals present and their concentrations can be measured by EPA Method 6010.

(b) Fine particulates. For both cement-based and lime/pozzolan-based processes, the literature states that very fine solid materials (i.e., those that pass through a No. 200 mesh sieve, 74 um particle size) can weaken the bonding between waste particles and cement by coating the particles. This coating can inhibit chemical bond formation and decrease the resistance of the material to leaching.

(c) Oil and grease. The presence of oil and grease in both cement-based and lime/pozzolan-based systems results in the coating of waste particles and the weakening of the bonding between the particle and the stabilizing agent. This coating can inhibit chemical bond formation and thereby decrease the resistance of the material to leaching.

(d) Organic compounds. The presence of organic compounds in the waste interferes with the chemical reactions and bond formation that inhibit curing of the stabilized material. This results in a stabilized waste that has decreased resistance to leaching.

(e) Sulfate and chlorides. The presence of certain inorganic compounds will interfere with the chemical reactions, weakening bond strength and prolonging setting and curing time. Sulfate and chloride compounds may reduce the dimensional stability of the cured matrix, thereby increasing leachability potential.

Accordingly, EPA will examine these constituents when making decisions regarding transfer of treatment standards based on stabilization.

(5) Design and operating parameters. In designing a stabilization system, the principal parameters that must be optimized so that the amount of leachable metal constituents is minimized are (a) selection of stabilizing agents and other additives, (b) ratio of waste to stabilizing agents and other additives, (c) degree of mixing, and (d) curing conditions.

(a) Selection of stabilizing agents and other additives. The stabilizing agent and additives used will determine the chemistry and structure of the stabilized material and will affect the leachability of the solid material. Stabilizing agents and additives must be carefully selected based on the chemical and physical characteristics of the waste to be stabilized. For example, the amount of sulfates in a waste must be considered when a choice is being made between a lime/pozzolan- and a portland cement-based system.

To select the type of stabilizing agents and additives, the waste should first be tested in the laboratory with a variety of materials to determine the best combination.

(b) Amount of stabilizing agents and additives. The amount of stabilizing agents and additives is a critical parameter since it is necessary to have sufficient stabilizing materials in the mixture to properly bind the waste constituents of concern, making them less susceptible to leaching. The appropriate weight ratios of waste to stabilizing agent and other additives are established empirically by setting up a series of laboratory tests that allow separate leachate testing of different mix ratios. The ratio of water to stabilizing agent (including water in waste) will also impact the strength and leaching characteristics of the stabilized material. Too much water will cause low strength; too little will make mixing difficult and, more important, may not allow the chemical reactions that bind the hazardous constituents to be fully completed.

(c) Mixing. Mixing is necessary to ensure homogeneous distribution of the waste and the stabilizing agents. Conditions include the type and duration of mixing. Both undermixing and overmixing are undesirable. The first condition results in a nonhomogeneous mixture; therefore, areas will exist within the waste where waste particles are neither chemically bonded to the stabilizing agent nor physically held within the lattice structure. Overmixing, on the other hand, may inhibit gel formation and ion adsorption in some stabilization systems. As with the relative amounts of waste, stabilizing agent, and additives within the system, optimal mixing conditions generally are determined through laboratory tests. During treatment it is important to monitor the degree (i.e., type and duration) of mixing to ensure that it reflects design conditions.

(d) Curing conditions. The curing conditions include the duration of curing and ambient curing conditions (temperature and humidity). The duration of curing is a critical parameter to ensure that the waste particles have had sufficient time in which to form stable chemical bonds and/or lattice structures. The time necessary for complete stabilization depends upon the waste type and the stabilization used. The performance of the stabilized waste (i.e., the levels of constituents in the leachate) will be highly dependent upon whether complete stabilization has occurred. Higher temperatures and lower humidity increase the rate of curing by increasing the rate of evaporation of water from the solidification mixtures. If temperatures are too high, however, the evaporation rate can be excessive and result in too little water being available for completion of the stabilization reaction. The duration of the curing process should also be determined during the design stage and typically will be between 7 and 28 days.

4. PERFORMANCE DATA BASE

For the treatment system tested by the Agency (see Figure 4-1), Tables 4-1 to 4-11 provide concentrations of BDAT list metals present in the untreated waste streams, the treated wastewater, and the total concentration and the TCLP values of the treated nonwastewater (cake). The untreated waste streams are mixed and then processed in the treatment system. The composition of the waste stream resulting from the mixing is also shown in Tables 4-1 to 4-11. The treated K062 wastewater is the filtrate from the vacuum filter, and the treated K062 nonwastewater (cake) is the filter cake from the vacuum filter. In the data from the 11 sample sets, chromium, copper, and nickel were present in the highest concentrations in the untreated K062 waste. The concentration data for the untreated waste also show that arsenic and zinc were present in much lower concentrations.

The chemical precipitation treatment operations on all 11 sets were carried out in the design pH range of 8 to 10.

As described in Section 3.2, the waste characteristics affecting chromium reduction, chemical precipitation, and precipitate dewatering for the untreated waste K062 are suspended solids concentration, dissolved solids concentration, oil and grease content, and complexed metal concentration. For suspended solids, the observed concentrations in the untreated waste were <1 to 100 mg/l; for dissolved solids, 1,900 to 118,100 mg/l; and for oil and grease, <0.2 to 6 mg/l. Tests for metal complexes were not performed.

A comment received on the Notice of Availability and Request for Comments on the California List Constituents (51 FR 2991) suggested that K062 wastewater and nonwastewater can be treated by high temperature metals recovery. At this time, the applicability of high temperature metals recovery to all K062 nonwastewaters has not been sufficiently verified in order to develop additional treatment standards. The concentrations and identity of metals in K062 wastewater vary widely depending on the specific steel being pickled. EPA has not been able to define any particular subcategories of K062 nonwastewater that would be amenable to a particular recovery process.

The performance data for the system tested by the Agency indicate that the system appears to be well designed and well operated. The low concentration of BDAT list metals in treated wastewater and low TCLP metal values for treated nonwastewater show that the K062 waste was effectively treated. Therefore, chromium reduction followed by chemical precipitation, and settling, filtering, and dewatering of solids, is a demonstrated treatment technology train for K062 wastes.

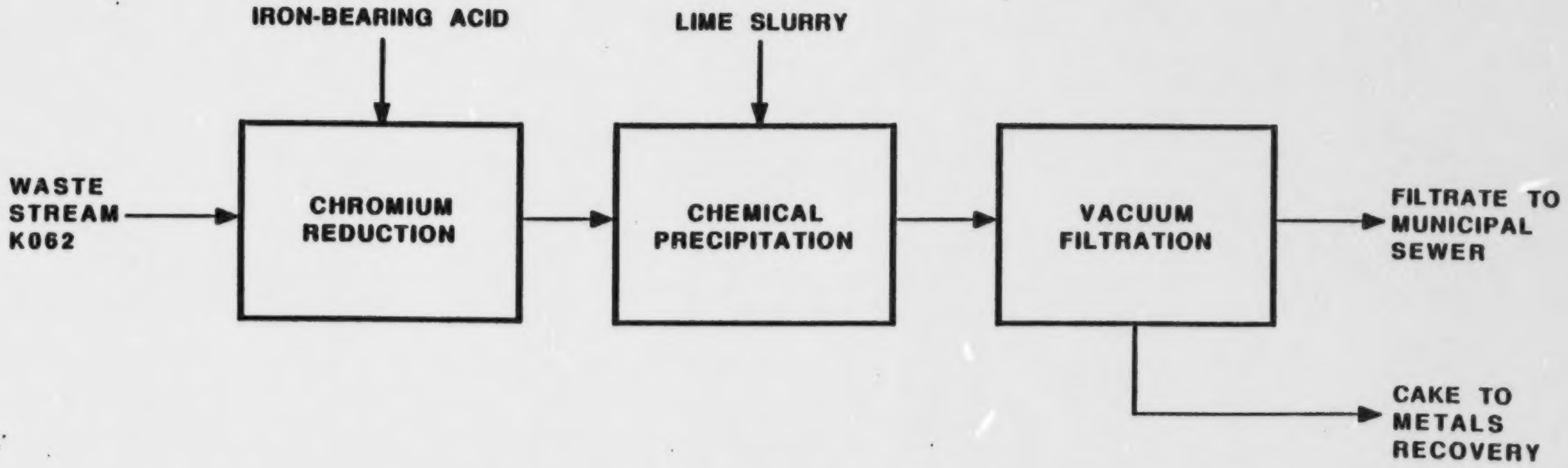

IRON-BEARING ACID
LIME SLURRY
WASTE STREAM K062
CHROMIUM REDUCTION
CHEMICAL PRECIPITATION
VACUUM FILTRATION
FILTRATE TO MUNICIPAL SEWER
CAKE TO METALS RECOVERY

FIGURE 4-2 SCHEMATIC DIAGRAM OF TREATMENT PROCESS FOR KO62 WASTES

Table 4-1 Treatment Performance Data for K062 - EPA-Collected Data

Sample Set #1

Constituent	Untreated K062 waste (mg/l) Sample no. 801	Untreated K062 waste (mg/l) Sample no. 802	Untreated waste composite[a] (mg/l) Sample no. 805	Treated waste (wastewater) (mg/l) Sample no. 806	Treated waste K062 (nonwastewater) Total (mg/kg) Sample no. 807	TCLP (mg/l) 807
Arsenic	3	<1	<1	<0.1	<1	<0.010
Chromium (hexavalent)	I	I	893	0.011	1.43	-
Chromium (total)	1800	7000	2581	0.12	7300	<0.050
Copper	865	306	138	0.21	380	-
Lead	<10	<10	64	<0.01	2800	<0.10
Nickel	3200	2600	471	0.33	1400	-
Zinc	<2	<2	116	0.125	1300	-

Design and Operating Data

	Design value	Operating value
pH	8-10	9

I = Color interference.
- = Not analyzed.

[a] The untreated waste composite is a mixture of the untreated K062 waste streams shown on this table, along with other non-K062 waste streams.

Table 4-2 Treatment Performance Data for K062 - EPA-Collected Data

Sample Set #2

Constituent	Untreated K062 waste (mg/l) Sample no. 801	Untreated K062 waste (mg/l) Sample no. 802	Untreated waste composite[a] (mg/l) Sample no. 813	Treated waste (wastewater) (mg/l) Sample no. 814	Treated waste K062 Total (mg/kg) Sample no. 815	Treated waste K062 TCLP (mg/l) Sample no. 815
Arsenic	3	<1	<1	<0.1	1	<0.010
Chromium (hexavalent)	I	I	807	0.12	1.04	-
Chromium (total)	1800	7000	2279	0.19	7400	<0.050
Copper	865	306	133	0.15	400	-
Lead	<10	<10	54	<0.01	1200	<0.10
Nickel	3200	2600	470	0.33	1200	-
Zinc	<2	<2	4	0.115	2100	-

Design and Operating Data

	Design value	Operating value
pH	8-10	9

I = Color interference.

- = Not analyzed.

[a] The untreated waste composite is a mixture of the untreated K062 waste streams shown on this table, along with other non-K062 waste streams.

Table 4-3 Treatment Performance Data for K062 - EPA-Collected Data

Sample Set #3

Constituent	Untreated K062 waste (mg/l) Sample no. 817	Untreated K062 waste (mg/l) Sample no. 802	Untreated waste composite[a] (mg/l) Sample no. 821	Treated waste (wastewater) (mg/l) Sample no. 822	Treated waste K062	
					Total (mg/kg) Sample no. 823	TCLP (mg/l) Sample no. 823
Arsenic	3	<1	<1	<0.1	2	0.012
Chromium (hexavalent)	I	I	775	I	I	-
Chromium (total)	1700	7000	1990	0.20	4000	<0.050
Copper	425	306	133	0.21	445	-
Lead	<10	<10	<10	<0.01	118	<0.10
Nickel	100310	2600	16330	0.33	3900	-
Zinc	7	<2	3.9	0.140	112	-

Design and Operating Data

	Design value	Operating value
pH	8-10	10

I = Color interference.
- = Not analyzed.

[a] The untreated waste composite is a mixture of the untreated K062 waste streams shown on this table, along with other non-K062 waste streams.

Table 4-4 Treatment Performance Data for K062 - EPA-Collected Data

Sample Set #4

Constituent	Untreated K062 waste (mg/l) Sample no. 827	Untreated K062 waste (mg/l) Sample no. 802	Untreated K062 waste (mg/l) Sample no. 817	Untreated waste composite[a] (mg/l) Sample no. 829	Treated waste (wastewater) (mg/l) Sample no. 830	Treated waste K062 Total (mg/kg) Sample no 831	Treated waste K062 TCLP (mg/l) Sample no 831
Arsenic	2	<1	3	<1	<1	2	0.015
Chromium (hexavalent)	1	I	I	0.6	0.042	0.92	-
Chromium (total)	142	7000	1700	556	0.10	2400	0.068
Copper	42	306	425	88	0.07	292	-
Lead	<10	<10	<10	<10	<0.01	99	<0.10
Nickel	650	2600	41000	6610	0.33	2700	-
Zinc	3	<2	7	84	1.62	1200	-

Design and Operating Data

	Design value	Operating value
pH	8-10	9

I = Color interference.

- = Not analyzed.

[a] The untreated waste composite is a mixture of the untreated K062 waste streams shown on this table, along with other non-K062 waste streams.

Table 4-5 Treatment Performance Data for K062 - EPA-Collected Data

Sample Set #5

Constituent	Untreated K062 waste (mg/l) Sample no. 801	Untreated K062 waste (mg/l) Sample no. 802	Untreated K062 waste (mg/l) Sample no. 817	Untreated waste composite[a] (mg/l) Sample no. 837	Treated waste (wastewater) (mg/l) Sample no. 838	Treated waste K062 Total (mg/kg) Sample no. 839	Treated waste K062 TCLP (mg/l) Sample no. 839
Arsenic	3	<1	3	<1	<0.1	1	<0.010
Chromium (hexavalent)	I	I	I	917	0.058	0.741	-
Chromium (total)	1800	7000	1700	2236	0.11	11500	<0.050
Copper	865	306	425	91	180.14	375	-
Lead	<10	<10	<10	18	0.01	525	<0.10
Nickel	3200	2600	41000	1414	0.31	3300	-
Zinc	<2	<2	7	71	0.125	410	-

Design and Operating Data

	Design value	Operating value
pH	8-10	8

I = Color interference.

- = Not analyzed.

[a] The untreated waste composite is a mixture of the untreated K062 waste streams shown on this table, along with other non-K062 waste streams.

Table 4-6 Treatment Performance Data for K062 - EPA-Collected Data

Sample Set #6

Constituent	Untreated K062 waste (mg/l) Sample no. 801	Untreated K062 waste (mg/l) Sample no. 802	Untreated waste composite[a] (mg/l) Sample no. 845	Treated waste (wastewater) (mg/l) Sample no. 846	Treated waste K062 Total (mg/kg) Sample no. 847	Treated waste K062 TCLP (mg/l) Sample no. 847
Arsenic	3	<1	<1	<0.1	1	<0.010
Chromium (hexavalent)	I	I	734	I	1.775	-
Chromium (total)	1800	7000	2548	0.10	10000	<0.050
Copper	865	306	149	0.12	432	-
Lead	<10	<10	<10	<0.01	42	<0.10
Nickel	3200	2600	588	0.33	1600	-
Zinc	<2	<2	4	0.095	68	-

Design and Operating Data

	Design value	Operating value
pH	8-10	8

I = Color interference.
- = Not analyzed.

[a] The untreated waste composite is a mixture of the untreated K062 waste streams shown on this table, along with other non-K062 waste streams.

Table 4-7 Treatment Performance Data for K062 - EPA-Collected Data

Sample Set #7

Constituent	Untreated K062 waste (mg/l) Sample no. 801	Untreated K062 waste (mg/l) Sample no. 802	Untreated waste composite[a] (mg/l) Sample no. 853	Treated waste (wastewater) (mg/l) Sample no. 854	Treated waste K062	
					Total (mg/kg) Sample no. 855	TCLP (mg/l) Sample no. 855
Arsenic	3	<1	<1	<0.1	1	<0.010
Chromium (hexavalent)	I	I	769	0.12	I	-
Chromium (total)	1800	7000	2314	0.12	16300	<0.050
Copper	865	306	72	0.16	330	-
Lead	<10	<10	108	<0.01	375	<0.10
Nickel	3200	2600	426	0.40	1700	-
Zinc	<2	<2	171	0.115	375	-

Design and Operating Data

	Design value	Operating value
pH	8-10	9

I = Color interference.

- = Not analyzed.

[a] The untreated waste composite is a mixture of the untreated K062 waste streams shown on this table, along with other non-K062 waste streams.

Table 4-8 Treatment Performance Data for K062 - EPA-Collected Data

Sample Set #6

Constituent	Untreated K062 waste (mg/l) Sample no. 859	Untreated K062 waste (mg/l) Sample no. 801	Untreated waste composite[a] (mg/l) Sample no. 861	Treated waste (wastewater) (mg/l) Sample no. 862	Treated waste K062 Total (mg/kg) Sample no. 863	Treated waste K062 TCLP (mg/l) Sample no. 863
Arsenic	<1	3	<1	<0.1	4	0.011
Chromium (hexavalent)	0.220	I	0.13	<0.01	0.116	-
Chromium (total)	15	1800	831	0.15	2800	<0.050
Copper	151	865	217	0.16	688	-
Lead	<10	<10	212	<0.01	300	<0.10
Nickel	90	3200	659	0.36	2600	-
Zinc	7	9	151	0.130	420	-

Design and Operating Data

	Design value	Operating value
pH	8-10	9

I = Color interference.

- = Not analyzed.

[a] The untreated waste composite is a mixture of the untreated K062 waste streams shown on this table, along with other non-K062 waste streams.

Table 4-8 Treatment Performance Data for K062 - EPA-Collected Data

Sample Set #6

Constituent	Untreated K062 waste (mg/l) Sample no. 859	Untreated K062 waste (mg/l) Sample no. 801	Untreated waste composite[a] (mg/l) Sample no. 861	Treated waste (wastewater) (mg/l) Sample no. 862	Treated waste K062 Total (mg/kg) Sample no. 863	TCLP (mg/l) 863
Arsenic	<1	3	<1	<0.1	4	0.011
Chromium (hexavalent)	0.220	I	0.13	<0.01	0.116	-
Chromium (total)	15	1800	831	0.15	2800	<0.050
Copper	151	865	217	0.16	688	-
Lead	<10	<10	212	<0.01	300	<0.10
Nickel	90	3200	669	0.36	2600	-
Zinc	7	9	151	0.130	420	-

Design and Operating Data

	Design value	Operating value
pH	8-10	9

I = Color interference.
- = Not analyzed.

[a] The untreated waste composite is a mixture of the untreated K062 waste streams shown on this table, along with other non-K062 waste streams.

Table 4-9 Treatment Performance Data for K062 - EPA-Collected Data

Sample Set #9

Constituent	Untreated K062 waste (mg/l) Sample no. 867	Untreated K062 waste (mg/l) Sample no. 801	Untreated K062 waste (mg/l) Sample no. 802	Untreated waste composite[a] (mg/l) Sample no. 869	Treated waste (wastewater) (mg/l) Sample no. 870	Treated waste K062 Total (mg/kg) Sample no. 871	Treated waste K062 TCLP (mg/l) Sample no. 871
Arsenic	<0.1	3	<1	<1	<0.1	3	0.011
Chromium (hexavalent)	0.079	I	I	0.07	0.041	I	-
Chromium (total)	6	1800	7000	939	0.10	3400	<0.050
Copper	5	865	306	225	0.08	775	-
Lead	<1	<10	<10	<10	<0.01	85	<0.10
Nickel	4	3200	2600	940	0.33	3500	-
Zinc	0.4	<2	<2	5	0.06	150	-

Design and Operating Data

	Design value	Operating value
pH	8-10	10

I = Color interference.

- = Not analyzed.

[a] The untreated waste composite is a mixture of the untreated K062 waste streams shown on this table, along with other non-K062 waste streams.

Table 4-10 Treatment Performance Data for
K062 - EPA-Collected Data

Sample Set #10

Constituent	Untreated K062 waste (mg/l) Sample no. 801	Untreated waste composite[a] (mg/l) Sample no. 885	Treated waste (wastewater) (mg/l) Sample no. 862	Treated waste K062 Total (mg/kg) Sample no. 863	Treated waste K062 TCLP (mg/l) Sample no. 863
Arsenic	<3	<1	<0.10	5	0.016
Chromium (hexavalent)	I	0.08	0.106	0.078	-
Chromium (total)	1800	395	0.12	4400	<0.050
Copper	865	191	0.14	758	-
Lead	<10	<10	<0.01	28	<0.10
Nickel	3200	712	0.33	4700	-
Zinc	<2	5	0.070	43	-

Design and Operating Data

	Design value	Operating value
pH	8-10	9

I = Color interference.
- = Not analyzed.

[a] The untreated waste composite is a mixture of the untreated K062 waste streams shown on this table, along with other non-K062 waste streams.

1665g

Table 4-11 Treatment Performance Data for K062 - EPA-Collected Data

Sample Set #11

Constituent	Untreated K062 waste (mg/l) Sample no. 801	Untreated K062 waste (mg/l) Sample no. 859	Untreated waste composite[a] (mg/l) Sample no. 893	Treated waste (wastewater) (mg/l) Sample no. 894	Treated waste K062 Total (mg/kg) Sample no. 895	Treated waste K062 TCLP (mg/l) Sample no. 895
Arsenic	3	<1	<1	<0.10	3	<0.010
Chromium (hexavalent)	I	0.220	0.30	<0.01	1.240	-
Chromium (total)	1800	15	617	0.18	2100	<0.050
Copper	865	151	137	0.24	388	-
Lead	<10	<10	136	<0.01	200	<0.10
Nickel	3200	90	382	0.39	1600	-
Zinc	<2	7	135	0.100	325	-

Design and Operating Data

	Design value	Operating value
pH	8-10	9

I = Color interference.
- = Not analyzed.

[a] The untreated waste composite is a mixture of the untreated K062 waste streams shown on this table, along with other non-K062 waste streams.

5. IDENTIFICATION OF BEST DEMONSTRATED AND AVAILABLE TECHNOLOGY (BDAT)

This section presents the rationale for the determination of best demonstrated available technology (BDAT) for K062 nonwastewater and wastewater. As discussed in Section 1, the Agency examines all available data for the technologies that have been demonstrated for a particular waste to determine if one of the demonstrated technologies performs significantly better than another. Next, the "best" performing of these technologies is evaluated to determine whether it is "available," i.e., whether it is (1) commercially available and (2) provides "substantial" treatment of the waste.

K062 waste is a nonwastewater. Demonstrated technologies for this waste, however, produce both nonwastewater and wastewater residuals. BDAT must therefore be identified for both types of waste streams.

5.1 Nonwastewater

Demonstrated treatments for K062 nonwastewater include (1) a treatment train consisting of chromium reduction, followed by chemical precipitation, and settling, filtering, and dewatering of solids and (2) high temperature metals recovery. At this time, the applicability of high temperature metals recovery to all K062 nonwastewater has not been sufficiently verified in order to develop additional treatment standards. The concentrations and identity of metals in K062 wastewater vary widely depending on the specific steel being pickled. EPA has not been able to define any particular subcategories of K062 nonwastewater that would be amenable to a particular recovery process.

The Agency has data on the performance of chromium reduction, chemical precipitation, and sludge dewatering (vacuum filtration). All of these data were obtained from a well-designed and well-operated system and therefore all may be used to compare performances of demonstrated technologies. The Agency also has data on the performance of high temperature metals recovery, but these data are from tests in which K062 wastes were mixed with other similar wastes; it is therefore not possible to isolate the performance of this technology on K062 wastes alone. Nevertheless, based on the results of performance tests for chromium reduction, followed by chemical precipitation, and settling, filtering, and dewatering of solids, the Agency has no reason to believe that the addition of high temperature metals recovery would improve overall treatment performance. It therefore determines that the treatment train of chromium reduction, followed by chemical precipitation, and settling, filtering, and dewatering of solids is "best" for K062 nonwastewater.

This treatment train is readily available commercially, fulfilling the first criterion for available treatment. It also achieves substantial treatment. Available data come from a test of the Envirite treatment system on mixed metal-bearing nonwastewater; these data show reductions of total chromium from 893 mg/l to nondetectable TCLP levels and of lead from 64 mg/l to nondetectable TCLP levels. These data represent accuracy-corrected values. Since the operating data collected during treatment of this waste show that the data represent the performance of a well-designed and well-operated system, all values were used in concluding that this system provides substantial treatment of metal-bearing nonwastewater to those that would be associated with treatment of K062.

The Agency therefore determines that chromium reduction, followed by chemical precipitation, and settling, filtering, and dewatering of solids, are BDAT for K062 nonwastewater.

For the residual nonwastewater stream produced by treatment of K062, the Agency determines that no further treatment is necessary because BDAT metals of concern, for which analysis was conducted, are reduced to below treatable levels. The Agency therefore determines that chromium reduction, followed by chemical precipitation, and settling, filtering, and dewatering of solids, are also BDAT for residuals from K062 nonwastewater treatment.

5.2 Wastewater

As noted above, treatment of K062 by chromium reduction, chemical precipitation, and sludge dewatering (vacuum filtration) produces a wastewater residual. Available performance data for this treatment train (see Section 4) show that treatment levels achieved for the waste are substantial. Hexavalent chromium levels were reduced from 893 mg/l in the untreated waste to 0.011 mg/l in the residual wastewater; total chromium from 2,581 mg/l in the untreated waste to 0.12 mg/l; copper from 138 mg/l to 0.21; nickel from 471 mg/l to 0.33; zinc from 116 mg/l to 0.125; and lead from 64 mg/l to below detection limits in the wastewater.

The Agency has no evidence to suggest or reason to believe that any further precipitation process would significantly improve on this level of treatment performance. It therefore determines that no additional treatment of K062 wastewater residuals is necessary, and that chromium reduction, followed by chemical precipitation, and settling, filtering, and dewatering of solids, are also BDAT for K062 wastewater residuals.

6. SELECTION OF REGULATED CONSTITUENTS

As discussed in Section 1, the Agency has developed a list of hazardous constituents (see Table 1-1) from which the constituents to be regulated are selected. EPA may revise this list as additional data and information become available. The list is divided into the following categories: volatile organics, semivolatile organics, metals, other inorganics, organochlorine pesticides, phenoxyacetic acid herbicides, organophosphorous pesticides, PCBs, and dioxins and furans.

This section describes the step by step process used to select the pollutants to be regulated. The selected pollutants must be present in the untreated waste and must be treatable by the chosen BDAT, as discussed in Section 5.

6.1 Identification of Major Constituents in K062

In the previous section, the Agency selected the best demonstrated treatment technology for treating K062 wastes. The constituents chosen by the Agency for regulation are found in untreated wastes at treatable concentrations for the selected BDAT. Based on the analysis of the processes generating K062 wastes, as shown on the list of BDAT constituents presented in Table 6-1 (231 in number), the Agency does not expect that the following categories (containing 213 constituents) will be present in K062 wastes: volatile organics, semivolatile organics, organochlorine pesticides, phenoxyacetic acid herbicides, organophosphorous pesticides, PCBs, and dioxins and furans. Therefore, the above-mentioned categories were not analyzed for in the K062 wastes tested by the Agency. Furthermore, the Agency has no data indicating that these categories would be present in K062 wastes. The remaining 19 constituents fall into the categories of metals and other inorganics.

6.2 Selection of Regulated Constituents

As discussed in Section 2, K062 primarily contains metals, other inorganics, and water. Of the 16 metals in the BDAT list of constituents, the Agency has data showing that antimony, barium, beryllium, cadmium, mercury, selenium, silver, and thallium are present below detectable levels in K062 wastes. However, the Agency does not believe that these metals are present at levels treatable by the chosen BDAT. Although vanadium was not analyzed for in the K062 waste tested by the Agency, it is not expected that vanadium will be present in K062 wastes at treatable levels. The metals found in treatable concentrations in the untreated K062 waste tested by the Agency are chromium and nickel. Data are also available that indicate that lead may be present at significant (i.e., treatable) concentrations in K062 wastes from pickling operations from leaded steels. Arsenic and zinc were detected at relatively low concentrations in the untreated waste tested by the Agency, and are expected to be treated along with the metals present at higher concentrations. Hexavalent chromium was detected at less than 1 mg/l in the untreated K062 waste for some data sets; for others, color interference prevented the analyses for hexavalent chromium. Copper was also present in treatable concentrations; however, EPA will not consider copper for regulation for reasons provided in the preamble to the final rule for First Thirds wastes. Based on these findings, the Agency has selected for regulation the following metals from the BDAT list of constituents: chromium, lead, and nickel. The solubilities of all these metals are lowest within the design and operating pH range for the BDAT, i.e., a pH range of 8 to 10. For hexavalent chromium, the Agency expects that a well-designed and well-operated chromium reduction system, included in the selected BDAT treatment train, will treat any hexavalent chromium.

The Agency is not regulating any of the other three BDAT list inorganic constituents that may be present in K062 wastes, as they will not be treated by the chosen BDAT. If in the future the Agency finds that these other inorganics require treatment, it will set treatment standards at that time.

The following table shows the constituents to be regulated and the concentration ranges at which they have been reported in the data available to the Agency.

List of regulated constituents	Range present in the untreated K062 waste (mg/l)
Chromium	6 to 7,000
Lead	0.12 to 1,550
Nickel	4 to 100,310

Table 6-1 Status of BDAT List Constituent Presence in Untreated K062 Waste

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Volatile organics		
222.	Acetone	NA	
1.	Acetonitrile	NA	
2.	Acrolein	NA	
3.	Acrylonitrile	NA	
4.	Benzene	NA	
5.	Bromodichloromethane	NA	
6.	Bromomethane	NA	
223.	n-Butyl alcohol	NA	
7.	Carbon tetrachloride	NA	
8.	Carbon disulfide	NA	
9.	Chlorobenzene	NA	
10.	2-Chloro-1,3-butadiene	NA	
11.	Chlorodibromomethane	NA	
12.	Chloroethane	NA	
13.	2-Chloroethyl vinyl ether	NA	
14.	Chloroform	NA	
15.	Chloromethane	NA	
16.	3-Chloropropene	NA	
17.	1,2-Dibromo-3-chloropropane	NA	
18.	1,2-Dibromoethane	NA	
19.	Dibromomethane	NA	
20.	trans-1,4-Dichloro-2-butene	NA	
21.	Dichlorodifluoromethane	NA	
22.	1,1-Dichloroethane	NA	
23.	1,2-Dichloroethane	NA	
24.	1,1-Dichloroethylene	NA	
25.	trans-1,2-Dichloroethene	NA	
26.	1,2-Dichloropropane	NA	
27.	trans-1,3-Dichloropropene	NA	
28.	cis-1,3-Dichloropropene	NA	
29.	1,4-Dioxane	NA	
224.	2-Ethoxyethanol	NA	
225.	Ethyl acetate	NA	
226.	Ethyl benzene	NA	
30.	Ethyl cyanide	NA	
227.	Ethyl ether	NA	
31.	Ethyl methacrylate	NA	
214.	Ethylene oxide	NA	
32.	Iodomethane	NA	
33.	Isobutyl alcohol	NA	
228.	Methanol	NA	
34.	Methyl ethyl ketone	NA	

Table 6-1 (Continued)

BDAT reference no	Constituent	Detection status[a]	Believed to be present
	Volatile organics (continued)		
229.	Methyl isobutyl ketone	NA	
35.	Methyl methacrylate	NA	
37.	.Methacrylonitrile	NA	
38.	Methylene chloride	NA	
230.	2-Nitropropane	NA	
39.	Pyridine	NA	
40.	1,1,1,2-Tetrachloroethane	NA	
41.	1,1,2,2-Tetrachloroethane	NA	
42.	Tetrachloroethene	NA	
43.	Toluene	NA	
44.	Tribromomethane	NA	
45.	1,1,1-Trichloroethane	NA	
46.	1,1,2-Trichloroethane	NA	
47.	Trichloroethene	NA	
48.	Trichloromonofluoromethane	NA	
49.	1,2,3-Trichloropropane	NA	
231.	1,1,2-Trichloro-1,2,2-trifluoroethane	NA	
50.	Vinyl chloride	NA	
215.	1,2-Xylene	NA	
216.	1,3-Xylene	NA	
217.	1,4-Xylene	NA	
	Semivolatile organics		
51.	Acenaphthalene	NA	
52.	Acenaphthene	NA	
53.	Acetophenone	NA	
54.	2-Acetylaminofluorene	NA	
55.	4-Aminobiphenyl	NA	
56.	Aniline	NA	
57.	Anthracene	NA	
58.	Aramite	NA	
59.	Benz(a)anthracene	NA	
218.	Benzal chloride	NA	
60.	Benzenethiol	NA	
61.	Deleted		
62.	Benzo(a)pyrene	NA	
63.	Benzo(b)fluoranthene	NA	
64.	Benzo(ghi)perylene	NA	
65.	Benzo(k)fluoranthene	NA	
66.	p-Benzoquinone	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Semivolatile organics (continued)		
67.	Bis(2-chloroethoxy)methane	NA	
68.	Bis(2-chloroethyl)ether	NA	
69.	Bis(2-chloroisopropyl)ether	NA	
70.	Bis(2-ethylhexyl)phthalate	NA	
71.	4-Bromophenyl phenyl ether	NA	
72.	Butyl benzyl phthalate	NA	
73.	2-sec-Butyl-4,6-dinitrophenol	NA	
74.	p-Chloroaniline	NA	
75.	Chlorobenzilate	NA	
76.	p-Chloro-m-cresol	NA	
77.	2-Chloronaphthalene	NA	
78.	2-Chlorophenol	NA	
79.	3-Chloropropionitrile	NA	
80.	Chrysene	NA	
81.	ortho-Cresol	NA	
82.	para-Cresol	NA	
232.	Cyclohexanone	NA	
83.	Dibenz(a,h)anthracene	NA	
84.	Dibenzo(a,e)pyrene	NA	
85.	Dibenzo(a,i)pyrene	NA	
86.	m-Dichlorobenzene	NA	
87.	o-Dichlorobenzene	NA	
88.	p-Dichlorobenzene	NA	
89.	3,3'-Dichlorobenzidine	NA	
90.	2,4-Dichlorophenol	NA	
91.	2,6-Dichlorophenol	NA	
92.	Diethyl phthalate	NA	
93.	3,3'-Dimethoxybenzidine	NA	
94.	p-Dimethylaminoazobenzene	NA	
95.	3,3'-Dimethylbenzidine	NA	
96.	2,4-Dimethylphenol	NA	
97.	Dimethyl phthalate	NA	
98.	Di-n-butyl phthalate	NA	
99.	1,4-Dinitrobenzene	NA	
100.	4,6-Dinitro-o-cresol	NA	
101.	2,4-Dinitrophenol	NA	
102.	2,4-Dinitrotoluene	NA	
103.	2,6-Dinitrotoluene	NA	
104.	Di-n-octyl phthalate	NA	
105.	Di-n-propylnitrosamine	NA	
106.	Diphenylamine	NA	
219.	Diphenylnitrosamine	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Semivolatile organics (continued)		
107.	1,2-Diphenylhydrazine	NA	
108.	Fluoranthene	NA	
109.	Fluorene	NA	
110.	Hexachlorobenzene	NA	
111.	Hexachlorobutadiene	NA	
112.	Hexachlorocyclopentadiene	NA	
113.	Hexachloroethane	NA	
114.	Hexachlorophene	NA	
115.	Hexachloropropene	NA	
116.	Indeno(1,2,3-cd)pyrene	NA	
117.	Isosafrole	NA	
118.	Methapyrilene	NA	
119.	3-Methylcholanthrene	NA	
120.	4,4'-Methylenebis (2-chloroaniline)	NA	
36.	Methyl methanesulfonate	NA	
121.	Naphthalene	NA	
122.	1,4-Naphthoquinone	NA	
123.	1-Naphthylamine	NA	
124.	2-Naphthylamine	NA	
125.	p-Nitroaniline	NA	
126.	Nitrobenzene	NA	
127.	4-Nitrophenol	NA	
128.	N-Nitrosodi-n-butylamine	NA	
129.	N-Nitrosodiethylamine	NA	
130.	N-Nitrosodimethylamine	NA	
131.	N-Nitrosomethylethylamine	NA	
132.	N-Nitrosomorpholine	NA	
133.	N-Nitrosopiperidine	NA	
134.	n-Nitrosopyrrolidine	NA	
135.	5-Nitro-o-toluidine	NA	
136.	Pentachlorobenzene	NA	
137.	Pentachloroethane	NA	
138.	Pentachloronitrobenzene	NA	
139.	Pentachlorophenol	NA	
140.	Phenacetin	NA	
141.	Phenanthrene	NA	
142.	Phenol	NA	
220.	Phthalic anhydride	NA	
143.	2-Picoline	NA	
144.	Pronamide	NA	
145.	Pyrene	NA	
146.	Resorcinol	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Semivolatile organics (continued)		
147.	Safrole	NA	
148.	1,2,4,5-Tetrachlorobenzene	NA	
149.	2,3,4,6-Tetrachlorophenol	NA	
150.	1,2,4-Trichlorobenzene	NA	
151.	2,4,5-Trichlorophenol	NA	
152.	2,4,6-Trichlorophenol	NA	
153.	Tris(2,3-dibromopropyl) phosphate	NA	
	Metals		
154.	Antimony	ND	
155.	Arsenic	<0.1-3	
156.	Barium	ND	
157.	Beryllium	ND	
158.	Cadmium	ND	
159.	Chromium (total)	2-12,400	
221.	Chromium (hexavalent)	0.005-19	
160.	Copper	5-865	
161.	Lead	0.12-1,550	
162.	Mercury	ND	
163.	Nickel	4-100,310	
164.	Selenium	ND	
165.	Silver	ND	
166.	Thallium	ND	
167.	Vanadium	NA	
168.	Zinc	<0.4-9	
	Inorganics other than metals		
169.	Cyanide	ND	
170.	Fluoride	NA	
171.	Sulfide	<6-215	
	Organochlorine pesticides		
172.	Aldrin	NA	
173.	alpha-BHC	NA	
174.	beta-BHC	NA	
175.	delta-BHC	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Organochlorine pesticides (continued)		
176.	gamma-BHC	NA	
177.	Chlordane	NA	
178.	DDD	NA	
179.	DDE	NA	
180.	DDT	NA	
181.	Dieldrin	NA	
182.	Endosulfan I	NA	
183.	Endosulfan II	NA	
184.	Endrin	NA	
185.	Endrin aldehyde	NA	
186.	Heptachlor	NA	
187.	Heptachlor epoxide	NA	
188.	Isodrin	NA	
189.	Kepone	NA	
190.	Methoxyclor	NA	
191.	Toxaphene	NA	
	Phenoxyacetic acid herbicides		
192.	2,4-Dichlorophenoxyacetic acid	NA	
193.	Silvex	NA	
194.	2,4,5-T	NA	
	Organophosphorous insecticides		
195.	Disulfoton	NA	
196.	Famphur	NA	
197.	Methyl parathion	NA	
198.	Parathion	NA	
199.	Phorate	NA	
	PCBs		
200.	Aroclor 1016	NA	
201.	Aroclor 1221	NA	
202.	Aroclor 1232	NA	
203.	Aroclor 1242	NA	
204.	Aroclor 1248	NA	
205.	Aroclor 1254	NA	
206.	Aroclor 1260	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Dioxins and furans		
207.	Hexachlorodibenzo-p-dioxins	NA	
208.	Hexachlorodibenzofurans	NA	
209.	Pentachlorodibenzo-p-dioxins	NA	
210.	Pentachlorodibenzofurans	NA	
211.	Tetrachlorodibenzo-p-dioxins	NA	
212.	Tetrachlorodibenzofurans	NA	
213.	2,3,7,8-Tetrachlorodibenzo-p-dioxin	NA	

ND = Not detected.

NA = Not analyzed.

X = Believed to be present based on an engineering analysis of the waste generating process.

Y = Believed to be present based on detection in treated residuals.

[a] Where concentrations are shown, units are mg/kg.

7. CALCULATION OF BDAT TREATMENT STANDARDS

In the previous section, EPA chose the constituents in the untreated K062 waste to be regulated. The purpose of this section is to calculate treatment standards for those regulated constituents. Details of the methodology are provided in Generic Quality Assurance Project Plan (QAPP) for the Land Disposal Restriction Program ("BDAT") (USEPA 1987a). As discussed in Section 6, the regulated constituents are chromium, lead, and nickel.

The BDAT treatment standards (1) are reflective of treatment data from a well-designed and well-operated treatment system, (2) account for analytical limitations, and (3) have been adjusted for variability owing to treatment, sampling, and analytical techniques and procedures.

The BDAT treatment standards for K062 were derived as follows.

7.1 Correction of Analytical Data

The raw analytical data for the regulated constituents for K062 were corrected for the analytical recovery by multiplying by their respective recovery-correction factors. The recovery-correction factors are obtained by dividing 100 by the corresponding percent recovery of the constituents. Presently the percent recovery values for the regulated K062 constituents are being taken from the Onsite Engineering Report for Horsehead Resource Development Co. for K061 (USEPA 1987b), since percent recovery values are not available for metal spikes and metal spike duplicates from the treatment data on K062. This is being done since all the metals that are being regulated in K062 were also analyzed for in

K061. However, for K061, ICP Method 6010 (SW-846) was used to analyze for chromium, lead, and nickel, whereas for K062, analysis for chromium was by Method 7190 (atomic absorption), lead by Method 7420 (atomic absorption), and nickel by Method 7520 (atomic absorption). The transferred percent recovery values for total composition are 68, 76, and 93 percent for chromium, lead, and nickel, respectively. The transferred percent recovery values for TCLP for chromium and lead are 68 and 76 percent, respectively. The corrected concentration values for the regulated constituents in the treated wastewater residuals are presented in Table 7-1 at the end of this section. The corrected TCLP values in the treated nonwastewater residuals are provided in Table 7-2.

7.2 Calculation of Variability Factors and Treatment Standards

Details of the treatment standard calculation methodology are given in Section 1. In summary, average values of corrected concentrations of the regulated pollutants in the treated residuals for the 11 data sets were calculated. Variability factors were then calculated by determining the logarithm of the concentration values of the regulated constituents in the treated wastewater residual stream and also for the TCLP values of the treated nonwastewater residual stream. Following these calculations, their logarithmic mean and logarithmic standard deviation were calculated. All these values were then applied to the formula for variability factor calculation (given in Appendix A). Table 7-3 presents the concentration of the regulated constituents for each treated wastewater sample. The table also shows the mean value, the calculated variability factor, and the treatment standard. The treatment standard is the product of the mean concentration and the variability factor. Table 7-4 shows the same procedure for the treated nonwastewater residual leachate (TCLP).

The Agency does not have treatment performance data on the treatment of K062 wastes containing lead. Therefore, the Agency is transferring treatment data for lead from lead-containing non-K062 wastes treated at Envirite, along with the K062 wastes tested by the Agency. The Agency expects that the mixed wastes referred to above, are at least as difficult to treat as K062 wastes containing lead. Accordingly, EPA believes that the level of performance achieved for lead in the wastes treated in the treatment system tested by the Agency, can be transferred to lead in K062 wastes.

In summary, the BDAT treatment standards for K062 are as follows:

Constituent	Treated residual (wastewater) total concentration (mg/l)	Treated residual (nonwastewater) TCLP (mg/l)
Chromium (total)	0.32	0.094
Lead	0.04	0.37
Nickel	0.44	-

Table 7-1 Calculation of Corrected Values for Regulated Constituents for Treated Wastewater - Total Composition

Constituent	Treated waste (mg/l)	Percent[a] recovery	Correction factor	Corrected value (mg/l)
Chromium (total)	0.12	68	1.47	0.1764
	0.12			0.1764
	0.20			0.294
	0.10			0.147
	0.11			0.162
	0.10			0.147
	0.12			0.1764
	0.15			0.2205
	0.10			0.147
	0.12			0.1764
	0.18			0.2646
Lead	<0.01	76	1.316	<0.0132
	<0.01			<0.0132
	<0.01			<0.0132
	<0.01			<0.0132
	0.01			0.0132
	<0.01			<0.0132
	<0.01			<0.0132
	<0.01			<0.0132
	<0.01			<0.0132
	<0.01			<0.0132
	<0.01			<0.0132
Nickel	0.33	93	1.075	0.35
	0.33			0.35
	0.33			0.35
	0.33			0.35
	0.31			0.33
	0.33			0.35
	0.40			0.43
	0.36			0.39
	0.33			0.35
	0.33			0.35
	0.39			0.42

[a] The percent recovery has been taken from Table 7-14 of the Onsite Engineering Report from Horsehead Resource Development Company (USEPA 1987).

Table 7-2 Calculation of Corrected Values for Regulated Constituents for Treated Nonwastewater - TCLP Values

Constituent	Treated waste (cake) TCLP(mg/l)	Percent[a] recovery	Correction factor	Corrected value (mg/l)
Chromium (total)	<0.050	68	1.47	<0.0735
	<0.050			<0.0735
	<0.050			<0.0735
	0.068			0.1000
	<0.050			<0.0735
	<0.050			<0.0735
	<0.050			<0.0735
	<0.050			<0.0735
	<0.050			<0.0735
	<0.050			<0.0735
	<0.050			<0.0735
Lead	<0.10	76	1.316	<0.132
	<0.10			<0.132
	<0.10			<0.132
	<0.10			<0.132
	<0.10			<0.132
	<0.10			<0.132
	<0.10			<0.132
	<0.10			<0.132
	<0.10			<0.132
	<0.10			<0.132
	<0.10			<0.132

[a] The percent recovery has been taken from Table 7-14 of the Onsite Engineering Report from Horsehead Resource Development Company (USEPA 1987).

Table 7-3 Calculation of the Treatment Standards for the Regulated Constituents - Treated Wastewater

Regulated constituent	Conc.	Mean	VF	Treatment standard total concentration (mg/l)
Chromium (total)	.1765	.1898	1.69	0.32
	.1765			
	.2941			
	.1471			
	.1618			
	.1471			
	.1765			
	.2206			
	.1471			
	.1765			
	.2647			
Lead	<0.0132	0.0132	2.8[a]	0.04
	<0.0132			
	<0.0132			
	<0.0132			
	0.0132			
	<0.0132			
	<0.0132			
	<0.0132			
	<0.0132			
	<0.0132			
	<0.0132			
Nickel	.3548	.3685	1.20	0.44
	.3548			
	.3548			
	.3548			
	.3333			
	.3548			
	.4301			
	.3871			
	.3548			
	.3548			
	.4194			

[a] For cases in which all values are at or below the detection limit, the variability factor is taken as 2.8.

Table 7-4 Calculation of the Treatment Standards for the Regulated Constituent - Treated Nonwastewater

Regulated constituent	Conc.	Mean	VF	Treatment standard TCLP values (mg/l)
Chromium (total)	<0.0735	0.0759	1.24	0.094
	<0.0735			
	<0.0735			
	0.1			
	<0.0735			
	<0.0735			
	<0.0735			
	<0.0735			
	<0.0735			
	<0.0735			
	<0.0735			
Lead	<0.132	0.132	2.8[a]	0.37
	<0.132			
	<0.132			
	<0.132			
	<0.132			
	<0.132			
	<0.132			
	<0.132			
	<0.132			
	<0.132			
	<0.132			

[a] For cases in which all values are at or below the detection limit, the variability factor is taken as 2.8.

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APPENDIX A

STATISTICAL METHODS

A.1 F Value Determination for ANOVA Test

As noted in Section 1.2, EPA is using the statistical method known as analysis of variance (ANOVA) to determine the level of performance that represents "best" treatment where more than one technology is demonstrated. This method provides a measure of the differences between data sets.

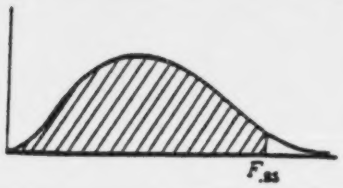
If the Agency found that the levels of performance for one or more technologies are not statistically different (i.e., the data sets are homogeneous), EPA would average the long-term performance values achieved by each technology and then multiply this value by the largest variability factor associated with any of the acceptable technologies. If EPA found that one technology performs significantly better (i.e., the data sets are not homogeneous), the "best" technology would be the technology that achieves the best level of performance, i.e., the technology with the lowest mean value.

To determine whether any or all of the treatment performance data sets are homogeneous using the analysis of variance method, it is necessary to compare a calculated "F value" to what is known as a "critical value." (See Table A-1.) These critical values are available in most statistics texts (see, for example, Statistical Concepts and Methods by Bhattacharyya and Johnson, 1977, John Wiley Publications, New York).

Table A-1

95th PERCENTILE VALUES FOR THE *F* DISTRIBUTION

n_1 = degrees of freedom for numerator
n_2 = degrees of freedom for denominator
(shaded area = .95)



n_2 \ n_1	1	2	3	4	5	6	8	12	16	20	30	40	50	100	∞
1	161.4	199.5	215.7	224.6	230.2	234.0	238.9	243.9	246.3	248.0	250.1	251.1	252.2	253.0	254.3
2	18.51	19.00	19.16	19.25	19.30	19.33	19.37	19.41	19.43	19.45	19.46	19.46	19.47	19.49	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.85	8.74	8.69	8.66	8.62	8.60	8.58	8.56	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.04	5.91	5.84	5.80	5.75	5.71	5.70	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.82	4.68	4.60	4.56	4.50	4.46	4.44	4.40	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.15	4.00	3.92	3.87	3.81	3.77	3.75	3.71	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.73	3.57	3.49	3.44	3.38	3.34	3.32	3.28	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.44	3.28	3.20	3.15	3.08	3.05	3.03	2.98	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.23	3.07	2.98	2.93	2.86	2.82	2.80	2.76	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.07	2.91	2.82	2.77	2.70	2.67	2.64	2.59	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	2.95	2.79	2.70	2.65	2.57	2.53	2.50	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.85	2.69	2.60	2.54	2.46	2.42	2.40	2.35	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.77	2.60	2.51	2.46	2.38	2.34	2.32	2.26	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.70	2.53	2.44	2.39	2.31	2.27	2.24	2.19	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.64	2.48	2.39	2.33	2.25	2.21	2.18	2.12	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.59	2.42	2.33	2.28	2.20	2.16	2.13	2.07	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.55	2.38	2.29	2.23	2.15	2.11	2.08	2.02	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.51	2.34	2.25	2.19	2.11	2.07	2.04	1.98	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.48	2.31	2.21	2.15	2.07	2.02	2.00	1.94	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.45	2.28	2.18	2.12	2.04	1.99	1.96	1.90	1.84
22	4.30	3.44	3.05	2.82	2.66	2.55	2.40	2.23	2.13	2.07	1.98	1.93	1.91	1.84	1.78
24	4.26	3.40	3.01	2.78	2.62	2.51	2.36	2.18	2.09	2.03	1.94	1.89	1.86	1.80	1.73
26	4.23	3.37	2.98	2.74	2.59	2.47	2.32	2.15	2.05	1.99	1.90	1.85	1.82	1.76	1.69
28	4.20	3.34	2.95	2.71	2.56	2.45	2.29	2.12	2.02	1.96	1.87	1.81	1.78	1.72	1.65
30	4.17	3.32	2.92	2.69	2.53	2.42	2.27	2.09	1.99	1.93	1.84	1.79	1.76	1.69	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.18	2.00	1.90	1.84	1.74	1.69	1.66	1.59	1.51
50	4.03	3.18	2.79	2.56	2.40	2.29	2.13	1.95	1.85	1.78	1.69	1.63	1.60	1.52	1.44
60	4.00	3.15	2.76	2.53	2.37	2.25	2.10	1.92	1.81	1.75	1.65	1.59	1.56	1.48	1.39
70	3.98	3.13	2.74	2.50	2.35	2.23	2.07	1.89	1.79	1.72	1.62	1.56	1.53	1.45	1.35
80	3.96	3.11	2.72	2.48	2.33	2.21	2.05	1.88	1.77	1.70	1.60	1.54	1.51	1.42	1.32
100	3.94	3.09	2.70	2.46	2.30	2.19	2.03	1.85	1.75	1.68	1.57	1.51	1.48	1.39	1.28
150	3.91	3.06	2.67	2.43	2.27	2.16	2.00	1.82	1.71	1.64	1.54	1.47	1.44	1.34	1.22
200	3.89	3.04	2.65	2.41	2.26	2.14	1.98	1.80	1.69	1.62	1.52	1.45	1.42	1.32	1.19
400	3.86	3.02	2.62	2.39	2.23	2.12	1.96	1.78	1.67	1.60	1.49	1.42	1.38	1.28	1.13
∞	3.84	2.99	2.60	2.37	2.21	2.09	1.94	1.75	1.64	1.57	1.46	1.40	1.32	1.24	1.00

Where the F value is less than the critical value, all treatment data sets are homogeneous. If the F value exceeds the critical value, it is necessary to perform a "pair wise F" test to determine if any of the sets are homogeneous. The "pair wise F" test must be done for all of the various combinations of data sets using the same method and equation as the general F test.

The F value is calculated as follows:

(i) All data are natural logtransformed.

(ii) The sum of the data points for each data set is computed (T_i).

(iii) The statistical parameter known as the sum of the squares between data sets (SSB) is computed:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^{2}}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^{2}}{N} \right]$$

where:

k = number of treatment technologies
n_i = number of data points for technology i
N = number of data points for all technologies
T_i = sum of natural logtransformed data points for each technology.

(iv) The sum of the squares within data sets (SSW) is computed:

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^{2}_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^{2}}{n_i} \right)$$

where:

$x_{i,j}$ = the natural logtransformed observations (j) for treatment technology (i).

(v) The degrees of freedom corresponding to SSB and SSW are calculated. For SSB, the degree of freedom is given by k-1. For SSW, the degree of freedom is given by N-k.

(vi) Using the above parameters, the F value is calculated as follows:

$$F = \frac{MSB}{MSW}$$

where:

$MSB = SSB/(k-1)$ and
$MSW = SSW/(N-k)$.

A computational table summarizing the above parameters is shown below.

Computational Table for the F Value

Source	Degrees of freedom	Sum of squares	Mean square	F value
Between	k-1	SSB	MSB = SSB/k-1	MSB/MSW
Within	N-k	SSW	MSW = SSW/N-k	

Below are three examples of the ANOVA calculation. The first two represent treatment by different technologies that achieve statistically similar treatment; the last example represents a case in which one technology achieves significantly better treatment than the other technology.

Example 1
Methylene Chloride

Steam stripping				Biological treatment			
Influent (μg/l)	Effluent (μg/l)	ln(effluent)	[ln(effluent)]^2	Influent (μg/l)	Effluent (μg/l)	ln(effluent)	[ln(effluent)]^2
1550.00	10.00	2.30	5.29	1960.00	10.00	2.30	5.29
1290.00	10.00	2.30	5.29	2568.00	10.00	2.30	5.29
1640.00	10.00	2.30	5.29	1817.00	10.00	2.30	5.29
5100.00	12.00	2.48	6.15	1640.00	26.00	3.26	10.63
1450.00	10.00	2.30	5.29	3907.00	10.00	2.30	5.29
4600.00	10.00	2.30	5.29				
1760.00	10.00	2.30	5.29				
2400.00	10.00	2.30	5.29				
4800.00	10.00	2.30	5.29				
12100.00	10.00	2.30	5.29				
Sum:							
-	-	23.18	53.76	-	-	12.46	31.79
Sample Size:							
10	10	10	-	5	5	5	-
Mean:							
3669	10.2	2.32	-	2378	13.2	2.49	-
Standard Deviation:							
3328.67	.63	.06	-	923.04	7.15	.43	-
Variability Factor:							
	1.15	-	-	-	2.48	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^{\,2}}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

$$MSB = SSB/(k-1)$$

$$MSW = SSW/(N-k)$$

Example 1 (Continued)

$F = MSB/MSW$

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of natural logtransformed data points for all technologies

T_i = sum of logtransformed data points for each technology

X_{ij} = the nat. logtransformed observations (j) for treatment technology (i)

$n_1 = 10,\ n_2 = 5,\ N = 15,\ k = 2,\ T_1 = 23.18,\ T_2 = 12.46,\ T = 35.64,\ T^2 = 1270.21$

$T_1^2 = 537.31 \quad T_2^2 = 155.25$

$$SSB = \left(\frac{537.31}{10} + \frac{155.25}{5}\right) - \frac{1270.21}{15} = 0.10$$

$$SSW = (53.76 + 31.79) - \left(\frac{537.31}{10} + \frac{155.25}{5}\right) = 0.77$$

$MSB = 0.10/1 = 0.10$

$MSW = 0.77/13 = 0.06$

$$F = \frac{0.10}{0.06} = 1.67$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	0.10	0.10	1.67
Within(W)	13	0.77	0.06	

The critical value of the F test at the 0.05 significance level is 4.67. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

Example 2
Trichloroethylene

Steam stripping Influent (µg/l)	Steam stripping Effluent (µg/l)	ln(effluent)	[ln(effluent)]^2	Biological treatment Influent (µg/l)	Biological treatment Effluent (µg/l)	ln(effluent)	[ln(effluent)]^2
1650.00	10.00	2.30	5.29	200.00	10.00	2.30	5.29
5200.00	10.00	2.30	5.29	224.00	10.00	2.30	5.29
5000.00	10.00	2.30	5.29	134.00	10.00	2.30	5.29
1720.00	10.00	2.30	5.29	150.00	10.00	2.30	5.29
1560.00	10.00	2.30	5.29	484.00	16.25	2.79	7.78
10300.00	10.00	2.30	5.29	163.00	10.00	2.30	5.29
210.00	10.00	2.30	5.29	182.00	10.00	2.30	5.29
1600.00	27.00	3.30	10.89				
204.00	85.00	4.44	19.71				
160.00	10.00	2.30	5.29				
Sum:							
-	-	26.14	72.92	-	-	16.59	39.52
Sample Size:							
10	10	10	-	7	7	7	-
Mean:							
2760	19.2	2.61	-	220	10.89	2.37	-
Standard Deviation:							
3209.6	23.7	.71	-	120.5	2.36	.19	-
Variability Factor:							
-	3.70	-	-	-	1.53	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

$$MSB = SSB/(k-1)$$

$$MSW - SSW/(N-k)$$

Example 2 (Continued)

$F = MSB/MSW$

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural logtransformed data points for each technology

X_{ij} = the natural logtransformed observations (j) for treatment technology (i)

$N_1 = 10$, $N_2 = 7$, $N = 17$, $k = 2$, $T_1 = 26.14$, $T_2 = 16.59$, $T = 42.73$, $T^2 = 1825.85$, $T_1^2 = 683.30$,

$T_2^2 = 275.23$

$$SSB = \left(\frac{683.30}{10} + \frac{275.23}{7}\right) - \frac{1825.85}{17} = 0.25$$

$$SSW = (72.92 + 39.52) - \left(\frac{683.30}{10} + \frac{275.23}{7}\right) = 4.79$$

$MSB = 0.25/1 = 0.25$

$MSW = 4.79/15 = 0.32$

$$F = \frac{0.25}{0.32} = 0.78$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	0.25	0.25	0.78
Within(W)	15	4.79	0.32	

The critical value of the F test at the 0.05 significance level is 4.54. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

Example 3
Chlorobenzene

Activated sludge followed by carbon adsorption				Biological treatment			
Influent (µg/l)	Effluent (µg/l)	ln(effluent)	$[\ln(\text{effluent})]^2$	Influent (µg/l)	Effluent (µg/l)	ln(effluent)	$\ln[(\text{effluent})]^2$
7200.00	80.00	4.38	19.18	9206.00	1083.00	6.99	48.86
6500.00	70.00	4.25	18.06	16646.00	709.50	6.56	43.03
6075.00	35.00	3.56	12.67	49775.00	460.00	6.13	37.58
3040.00	10.00	2.30	5.29	14731.00	142.00	4.96	24.60
				3159.00	603.00	6.40	40.96
				6756.00	153.00	5.03	25.30
				3040.00	17.00	2.83	8.01
Sum:							
-	-	14.49	55.20	-	-	38.90	228.34
Sample Size:							
4	4	4	-	7	7	7	-
Mean:							
5703	49	3.62	-	14759	452.5	5.56	-
Standard Deviation:							
1835.4	32.24	.95		16311.86	379.04	1.42	
Variability Factor:							
-	7.00	-	-	-	15.79	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

$$MSB = SSB/(k-1)$$

$$MSW = SSW/(N-k)$$

$$F = MSB/MSW$$

Example 3 (Continued)

where,

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural logtransformed data points for each technology

X_{ij} = the natural logtransformed observations (j) for treatment technology (i)

$N_1 = 4$, $N_2 = 7$, $N = 11$, $k = 2$, $T_1 = 14.49$, $T_2 = 38.90$, $T = 53.39$, $T^2 = 2850.49$, $T_1^2 = 209.96$

$T_2^2 = 1513.21$

$$SSB = \left(\frac{209.96}{4} + \frac{1513.21}{7}\right) - \frac{2850.49}{11} = 9.52$$

$$SSW = (55.20 + 228.34) - \left(\frac{209.96}{4} + \frac{1513.21}{7}\right) = 14.88$$

$MSB = 9.52/1 = 9.52$

$MSW = 14.88/9 = 1.65$

$F = 9.52/1.65 = 5.77$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	9.53	9.53	5.77
Within(W)	9	14.89	1.65	

The critical value of the F test at the 0.05 significance level is 5.12. Since the F value is larger than the critical value, the means are significantly different (i.e., they are heterogeneous). Activated sludge followed by carbon adsorption is "best" in this example because the mean of the long-term performance value, i.e., the effluent concentration, is lower.

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

A.2 Variability Factor

$$VF = \frac{C_{99}}{\text{Mean}}$$

where:

VF = estimate of daily maximum variability factor determined from a sample population of daily data;

C_{99} = estimate of performance values for which 99 percent of the daily observations will be below. C_{99} is calculated using the following equation: $C_{99} = \text{Exp}(y + 2.33\ Sy)$ where y and Sy are the mean and standard deviation, respectively, of the logtransformed data; and

Mean = average of the individual performance values.

EPA is establishing this figure as an instantaneous maximum because the Agency believes that on a day-to-day basis the waste should meet the applicable treatment standards. In addition, establishing this requirement makes it easier to check compliance on a single day. The 99th percentile is appropriate because it accounts for almost all process variability.

In several cases, all the results from analysis of the residuals from BDAT treatment are found at concentrations less than the detection limit. In such cases, all the actual concentration values are considered unknown and, hence, cannot be used to estimate the variability factor of the analytical results. Below is a description of EPA's approach for calculating the variability factor for such cases with all concentrations below the detection limit.

It has been postulated as a general rule that a lognormal distribution adequately describes the variation among concentrations. Agency data show that the treatment residual concentrations are distributed approximately lognormally. Therefore, the lognormal model has been used routinely in the EPA development of numerous regulations in the Effluent Guidelines program and is being used in the BDAT program. The variability factor (VF) was defined as the ratio of the 99th percentile (C_{99}) of the lognormal distribution to its arithmetic mean (Mean), as follows:

$$VF = \frac{C_{99}}{Mean}. \tag{1}$$

The relationship between the parameters of the lognormal distribution and the parameters of the normal distribution created by taking the natural logarithms of the lognormally distributed concentrations can be found in most mathematical statistics texts (see, for example, Distribution in Statistics-Volume 1 by Johnson and Kotz, 1970). The mean of the lognormal distribution can be expressed in terms of the mean (μ) and standard deviation (σ) of the normal distribution as follows:

$$C_{99} = \text{Exp}\ (\mu + 2.33\sigma) \tag{2}$$
$$\text{Mean} = \text{Exp}\ (\mu + 0.5\sigma^2). \tag{3}$$

By substituting (2) and (3) in (1), the variability factor can then be expressed in terms of σ as follows:

$$VF = \text{Exp}\ (2.33\ \sigma - 0.5\sigma^2). \tag{4}$$

For residuals with concentrations that are not all below the detection limit, the 99th percentile and the mean can be estimated from the actual analytical data and, accordingly, the variability factor (VF) can be estimated using equation (1). For residuals with concentrations that are below the detection limit, the above equations can be used in conjunction with the following assumptions to develop a variability factor.

- Assumption 1: The actual concentrations follow a lognormal distribution. The upper limit (UL) is equal to the detection limit. The lower limit (LL) is assumed to be equal to one-tenth of the detection limit. This assumption is based on the fact that data from well-designed and well-operated treatment systems generally fall within one order of magnitude.
- Assumption 2: The natural logarithms of the concentrations have a normal distribution with an upper limit equal to ln (UL) and a lower limit equal to ln (LL).
- Assumption 3: The standard deviation (σ) of the normal distribution is approximated by:

$$\sigma = [\ln(UL) - \ln(LL)] / [(2)(2.33)]$$
$$= [\ln(UL/LL)] / 4.66. \qquad (5)$$

(Note that when LL = (0.1)(UL) as in Assumption 1, then $\sigma = (\ln 10) / 4.66 = 0.494$.)

Substitution of the σ value from equation (5) into equation (4) yields the variability factor, VF, as shown:

$$VF = 2.8. \qquad (6)$$

APPENDIX B

ANALYTICAL METHODS AND QA/QC

The analytical methods used for analysis of the regulated constituents identified in Section 5 are listed in Table B-1. SW-846 methods (EPA's Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, Second Edition, July 1982) are used in most cases for determining total constituent concentrations. Leachate concentrations were determined using the Toxicity Characteristic Leaching Procedure (TCLP), published in 51 FR 1750, January 14, 1986.

Table B-1 Analytical Methods for Regulated Constituents

Regulated constituent	Extraction method	Analytical method		Reference
TOTAL COMPOSITION				
Chromium	Specified in analytical method	Chromium (atomic absorption, direct aspiration method)	7190	1
Copper	Specified in analytical method	Copper (atomic absorption, direct aspiration method)	220.1	3
Lead	Specified in analytical method	Lead (atomic absorption, direct aspiration method)	7420	1
Nickel	Specified in analytical method	Nickel (atomic absorption, direct aspiration method)	7520	1
TCLP EXTRACT				
Chromium		Toxicity Characteristic Leaching Procedure (TCLP)	51 FR 1750	2
Lead		Toxicity Characteristic Leaching Procedure (TCLP)	51 FR 1750	2

References:

1. USEPA. 1982. Environmental Protection Agency, Office of Solid Waste. Test methods for evaluating solid waste. 2nd ed. Washington, D.C.: U.S. Environmental Protection Agency.

2. USEPA. 1983. U.S. Environmental Protection Agency, Office of Solid Waste. Methods for chemical analysis of water and wastes. EPA-600/4-79-020. Washington, D.C.: U.S. Environmental Protection Agency.

3. USEPA. 1986. U.S. Environmental Protection Agency. Hazardous waste management systems; land disposal restrictions; Proposed Rule; Appendix I to Part 260 - Toxicity Characteristic Leaching Procedure (TCLP). 51 FR 1750, January 14, 1986.

APPENDIX C

METHOD OF MEASUREMENT FOR THERMAL CONDUCTIVITY

The comparative method of measuring thermal conductivity has been proposed as an ASTM test method under the name "Guarded, Comparative, Longitudinal Heat Flow Technique." A thermal heat flow circuit is used that is the analog of an electrical circuit with resistances in series. A reference material is chosen to have a thermal conductivity close to that estimated for the sample. Reference standards (also known as heat meters) having the same cross-sectional dimensions as the sample are placed above and below the sample. An upper heater, a lower heater, and a heat sink are added to the "stack" to complete the heat flow circuit. See Figure C-1.

The temperature gradients (analogous to potential differences) along the stack are measured with type K (chromel/alumel) thermocouples placed at known separations. The thermocouples are placed into holes or grooves in the references and also in the sample whenever the sample is thick enough to accommodate them.

For molten samples, pastes, greases, and other materials that must be contained, the material is placed into a cell consisting of a top and bottom of Pyrex 7740 and a containment ring of marinite. The sample is 2 inches in diameter and 0.5 inch thick. Thermocouples are not placed into the sample; rather, the temperatures measured in the Pyrex are extrapolated to give the temperature at the top and bottom surfaces of the sample material. The Pyrex disks also serve as the thermal conductivity reference material.

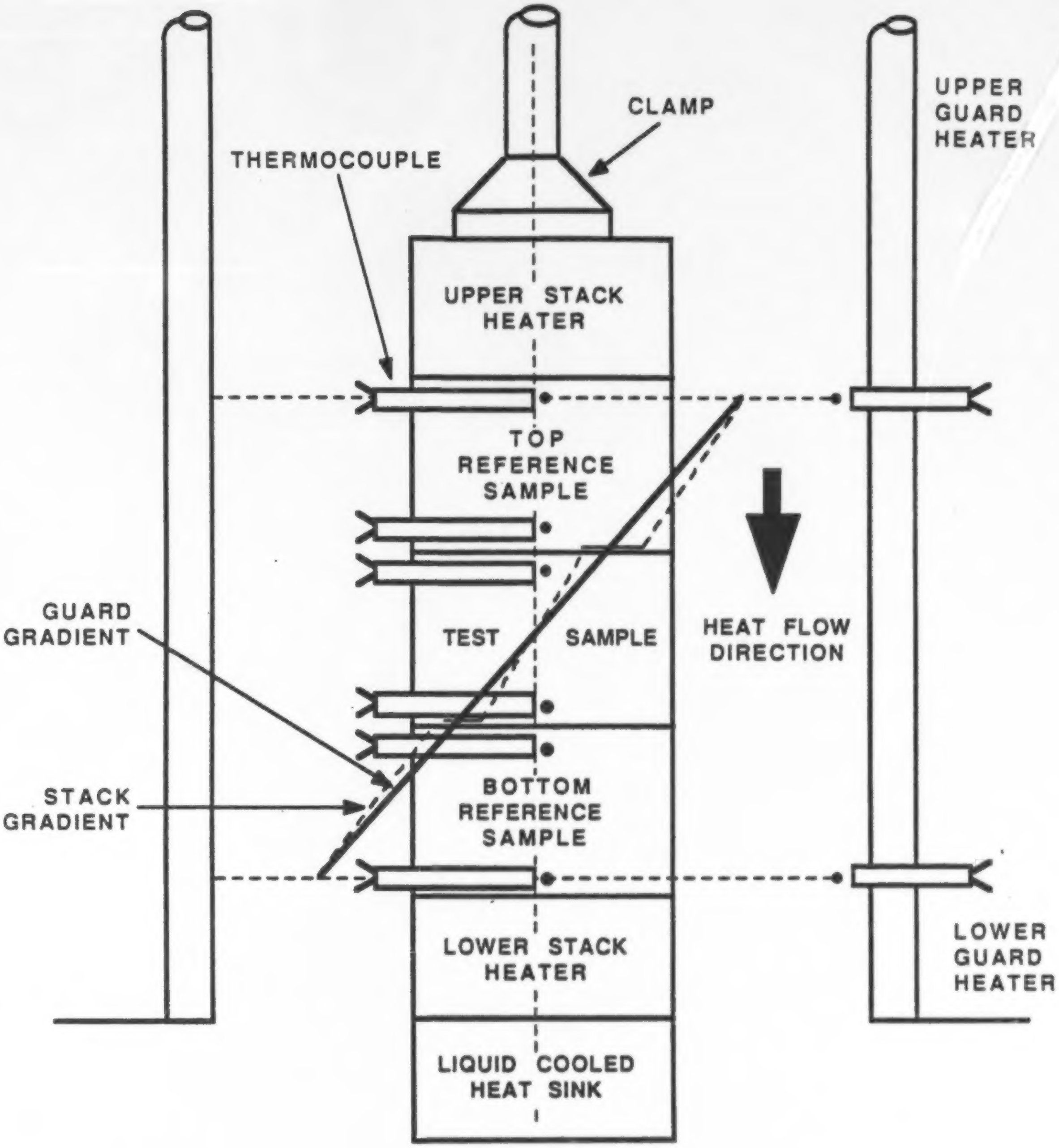

CLAMP
THERMOCOUPLE
UPPER
GUARD
HEATER
UPPER STACK
HEATER
TOP
REFERENCE
SAMPLE
GUARD
GRADIENT
TEST SAMPLE
HEAT FLOW
DIRECTION
STACK
GRADIENT
BOTTOM
REFERENCE
SAMPLE
LOWER STACK
HEATER
LOWER
GUARD
HEATER
LIQUID COOLED
HEAT SINK

FIGURE C-1 SCHEMATIC DIAGRAM OF THE COMPARATIVE METHOD

The stack is clamped with a reproducible load to ensure intimate contact between the components. To produce a linear flow of heat down the stack and reduce the amount of heat that flows radially, a guard tube is placed around the stack, and the intervening space is filled with insulating grains or powder. The temperature gradient in the guard is matched to that in the stack to further reduce radial heat flow.

The comparative method is a steady-state method of measuring thermal conductivity. When equilibrium is reached, the heat flux (analogous to current flow) down the stack can be determined from the references. The heat into the sample is given by

$$Q_{in} = \lambda_{top} (dT/dx)_{top}$$

and the heat out of the sample is given by

$$Q_{out} = \lambda_{bottom} (dT/dx)_{bottom}$$

where

λ = thermal conductivity

dT/dx = temperature gradient

and top refers to the upper reference, while bottom refers to the lower reference. If the heat were confined to flow down the stack, then Q_{in} and Q_{out} would be equal. If Q_{in} and Q_{out} are in reasonable agreement, the average heat flow is calculated from

$$Q = (Q_{in} + Q_{out})/2.$$

The sample thermal conductivity is then found from

$$\lambda_{sample} = Q/(dT/dx)_{sample}.$$